Electronic Version

Stylesheet Version v1.1.1

Description

Electromagnetic Propulsion Devices

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of the filing dates of provisional patent application: 60/319,820 filed December 30, 2002, provisional patent application: 60/320,208 filed May 21, 2003, and provisional patent application: 60/481,159.

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION.

[0002] The following invention is related electromagnetic propulsion devices such as rail guns. In rail guns a magnetic field perpendicular to an electrical current path through an armature interacts with the path current creating force on the armature which is perpendicular to both the current path and the magnetic field. The armature of a rail gun is located between and has electrical contact with the gun's parallel power rails. In the rail gun, armature current flow is resultant a voltage potential between the power

rails.

DESCRIPTION OF RELATED ART.

[0003] The source of the armature accelerating magnetic fields in a rail gun is often only its very large rail currents. The oldest patented rail gun inventions, those of Fauhon-Villeplee which include US Patent 1,370,200 have magnetic fields for armature acceleration supplied by electromagnets and/or permanent magnets arranged along the armature path between the power rails in addition to the magnetic fields of the rail currents. The power rails primary function is the supply of armature current. This design, although more cumbersome, permits more latitude in accelerator design.

[0004] Circular current patterns develop in the electrical currents traversing rail gun armatures. Associated with said circular current patterns are magnetic fields which are complimentary to the armature accelerating magnetic fields; i.e. the circular current pattern creates a magnetic field with south pole at the north pole of the accelerating field. This reduces the effective strength of the magnetic field which interacts with the armature current creating the armature accelerating force. The armatures of the inventions herein disclosed can utilize either armatures constructed of elec-

trically insulated conducting laminations parallel to the current path or solid armatures with a large number of current path parallel slits displaced from each other both in parallel and perpendicular directions in the planes of the armature.

[0005] Pyrotechnic projectile acceleration means such as gun powders and more esoteric explosives pervasive civilian and military armaments today have upper projectile velocity limits. These upper velocity limits are determined by the molecular velocity of the projectile propelling explosion gases at the maximum pressure and temperature permitted in the barrel.

[0006] Rail guns do not share this limitation. Therefore, the massive supporting power generation and distribution systems, which can include cryogenic equipment, required to supply the immense electric currents required by a rail gun are seen as acceptable overhead in propelling projectiles to hyper velocities.

[0007] With the effective development of gas cartridge fired power sources like those used for emergency power in some commercial and military aircraft, a significant reduction in the mass of rail gun support equipment should be possible.

[0008] A side effect of very large rail electric currents in rail guns is very large barrel stresses. The current induced barrel stresses are caused by the magnetic fields of each power rail electric current interaction with the electric current in the other power rail creating forces in the barrel proportional to the square of the current and directed to separate the rails. This problem has been addressed by a number of patents related to rail gun barrel structure and shielding.

[0009] The equations and examples herein are intended as aides to practitioners of the arts relevant the topic devices and are not part of the claimed devices, and the degree of their veracity is not intended to reflect adversely on the veracity, spirit, intent, merit or scope of this application for letters of patent.

[0010] A simplified formulae for a rail gun armature accelerating force due to one rail is:

1) $df = dq(U \times B) = (dQ \bullet dl/dt \times B) = I\, dl \times B = I\, dl \times \mu_o I/(2\pi r)$, where $\mu_o = 4\pi \times 10^{-7}$ H/m.

[0011] The force on the armature due to the current in both rails is then:

$$2) \qquad \text{Force} = 2[I^2 (4\pi \times 10^{-7})] \int_{r_o}^{r_1} dr/(2\pi r) = I^2 (4 \times 10^{-7}) \ln(r_a/r_o) \text{ Newton}$$

[0012] where r_o is effective radius of one of the rails and r_a is the

straight line distance from that rail to the second rail. The following example illustrate the magnitude of the currents required by conventional rail guns.

[0013] A hypothetical gun with a 11.43 mm cylindrical bore (.45 in.) and an approximate 0.6264 m (24 in.) barrel length, fires a 6.48 gram (100 grain) bullet with muzzle velocity of 1524 m/s (5000 ft/s). Ignoring air and barrel friction, a like muzzle velocity would also result from a steady force of 12344.2 N (2775 lbf) applied to the bullet during its 0.0008 second barrel traverse. At the muzzle the bullet has 7525 J (5550 ft-lbf) kinetic energy.

[0014] Applying the above rail gun force equation, 2, (with an r_a/r_o ratio of 5.4) for like performance of a 0.6264 m (24 in.) long rail gun propelled bullet and ignoring air and barrel friction and circuit resistance losses, a current of approximately 135,065 Amperes at a rail potential of 69.6 Volts is required to produce the 12344.2 N force on the armature for the 0.8 millisecond barrel traverse time.

[0015] For a like performance in a rail gun that has a 0.6264 m long barrel (24 in) cavity with a rectangular right section and a r_a/r_o ratio of 15, propelling a 6.48 gram (100 grain) flat projectile with a .0422 m (1.66 in.) long propulsion bus, an approximate current of 106,751 Amperes at a rail

potential of 88.1 volts is required to produce the 12344.2 Newton (2775 lbf) force on the armature for the 0.0008 second barrel traverse time.

BRIEF SUMMARY OF THE INVENTION

[0016] In the present invention, the total magnetic field strength interacting with the armature current is, or is increased resultant the circulation of the device current through barrel wall conductors immediately forward and immediately aft and closely proximal the armature current path during the armature barrel cavity traverse. The proper barrel wall conductor current circulation is maintained by current shunt means carried in the armature which interact with barrel wall conductor contact means, barrel rail including a power rail, and propulsion bus-aft shunt circuit means, and in embodiments wherein the wall conductor assembles and propulsion bus are element of a series circuit, an aft shunt-forward shunt circuit means.

[0017] The current circulation about the armature during its barrel cavity traverse in the invention increases the magnetic field strength acting on the armature current path per Ampere current; thereby, reducing the current requirement per newton force on the armature. The basic power requirements remain; (e.g 7525 Joules (5550 ft-lbf) in the

above example) however, the power profile is shifted from one with an extremely large current requirement to one with larger voltage requirements and significantly diminished current requirements. With their greatly reduced current requirements, devices of the invention might be designed to utilize commercially available power sources.

[0018] The reduced current requirement in rail guns of the invention reduces the power loss due to resistance, I^2R. Resistance losses increase linearly with increase in current path length and the number of sliding contacts; however, they are reduced by the square of the reduction in current flow. Therefore there is an expected reduction in overall power consumption in the invention.

[0019] The inclusion in addition to the two barrel rails that are power rails of a barrel rail which acts as a current path between and with continuous sliding electrical continuity the armature aft current shunt and the propulsion bus end there proximal , and when the design has two wall conductor assembles in series an additional barrel rail which acts as a current path between and with continuous electrical continuity the aft current shunt on the armature first side with the forward current shunt on the armature second side, eliminates the need for electric current pathways

in the armature which are parallel to its direction of travel (and the barrel cavity axis) and the proximal barrel rails electric current flow. Pathways which when extant create large forces of attraction between the armature and said rails and subsequent friction losses unless said forces are negated by using a tandem armature-tandem barrel cavity configuration discussed further below.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0020] Figure 1 is a portrayal of a prior art rail gun.;

[0021] Figure 2 is a portrayal of a prior art coaxial rail gun.;

[0022] Figure 3 is a portrayal of a Fauchon-Villeplee type rail gun of the prior art;

[0023] Figure 4 is an oblique partially cut away portrayal of an embodiment of the invention with an armature in the barrel;

[0024] Figure 5 is an oblique portrayal of the embodiment in figure 4 disassembled with armature;

[0025] Figure 6 is an oblique portrayal of an armature of the invention for use in invention embodiment portrayed in figure 4;

[0026] Figure 7 is an oblique portrayal of the armature in figure 6, disassembled;

[0027] Figure 8 is an oblique cut away portrayal of the breach end of the rail subassembly for the embodiment in figure 4.

[0028] Figure 9 is an oblique partially cutaway portrayal of the embodiment in figure 4 to illustrate current paths;

[0029] Figure 10 is an oblique partially cutaway portrayal of an embodiment of the invention with cylindrical armatures and barrel cavity;

[0030] Figure 11 is a view of an armature for the embodiment in figure 10;

[0031] Figure 12 is a view of the armature in figure 11, disassembled;

[0032] Figure 13 is an oblique cut away portrayal of the breach end of the rail subassembly for the embodiment in figure 10.;

[0033] Figure 14 is an oblique partially cutaway portrayal of an embodiment of the invention with asymmetric curved triangular wall cavity and which uses only wall conductors to effect armature propulsion;

[0034] Figure 15 is a portrayal of an armature of the invention for the embodiment in figure 14;

[0035] Figure 16 is an oblique portrayal of the armature in figure 15, disassembled;

[0036] Figure 17 is an oblique view of a section of the rail sub-assembly of the invention embodiment in figure 14;

[0037] Figure 18 is an oblique cutaway portrayal of the invention embodiment in figure 14 to illustrate current paths in the device;

[0038] Figure 19 is an oblique cutaway portrayal of an embodiment of the invention with two wall conductor assembles supplied current via a common armature current shunt;

[0039] Figure 20 is an oblique view of an armature for the device in figure 19;

[0040] Figure 21 is an oblique view of the armature in figure 20, disassembled;

[0041] Figure 22 is an oblique cutaway portrayal of the invention in figure 19 to illustrate current paths in one side of the device;

[0042] Figure 23 is an oblique cutaway portrayal of the invention in figure 19 to illustrate current paths in the second side of the device;

[0043] Figure 24 is an oblique view of an armature for an embodiment of the invention as in 19, but wherein the propulsion bus-aft shunt circuit means are carried in the armature;

[0044] Figure 25 is an oblique view of the armature in figure 24,

disassembled;

[0045] Figure 26 is an oblique cutaway view of mirror image embodiments of the invention physically combined in tandem;

[0046] Figure 27 is an oblique cutaway portrayal of an embodiment of the invention with two wall conductor assembles in series;

[0047] Figure 28 is a portrayal of the invention embodiment in figure 27 disassembled with an armature of the invention;

[0048] Figure 29 is an oblique view of section of the rail subassembly of the invention embodiment of figure 27;

[0049] Figure 30 is an oblique view of the second side of an armature (projectile) for the invention embodiment in figure 27;

[0050] Figure 31 is an oblique view of the first side of an armature (projectile) for the invention embodiment in figure 27;

[0051] Figure 32 is an oblique rear view on the second side of an armature of the invention embodiment in figure 27;

[0052] Figure 33 is an oblique view of the second side of an armature of the invention embodiment in figure 27, disassembled;

[0053] Figure 34 is a rear oblique first side view of an armature

of the invention embodiment in figure 27, disassembled;

[0054] Figure 35 is an oblique, cutaway view illustrating the current paths on the first side of the armature in the invention embodiment in figure 27;

[0055] Figure 36 is an oblique, cutaway view illustrating the current paths on the second side of the armature in the invention embodiment in figure 27;

[0056] Figure 37 is an oblique, cutaway view with armature of an embodiment of the invention with a cylindrical bore (barrel cavity) and two wall conductors in series;

[0057] Figure 38 is an oblique view of an armature for the invention embodiment in figure 37;

[0058] Figure 39 is an oblique view of the armature in figure 38, disassembled;

[0059] Figure 40 is an oblique view of a section of the rail subassembly of the invention embodiment in figure 37;

[0060] Figure 41 is an oblique cutaway portrayal of the invention embodiment in figure 37 to illustrate the current paths therein;

[0061] Figure 42 is an oblique view of a partially disassembled tandem armature with aft shunt-forward shunt circuit means and propulsion bus-aft shunt circuit means;

[0062] Figure 43 is an oblique view of a tandem barrel for the ar-

mature in figure 42;

[0063] Figure 44 is an oblique view of a barrel segment with a cylindrical cavity and twist.

DETAILED DESCRIPTION OF THE INVENTION

[0064] One of the simplest devices of the invention is illustrated in figures 4 through 9. The design has thin a rectangular barrel cavity, two barrel power rails one located at each of the narrow parallel edge walls of the cavity and armatures for propulsion therein and a single wall conductor assembly in one of the two barrel cavity wall segments formed between the power rails. The wall conductor assembly has a barrel bus proximal the power rail distal the shunt edge of an armature in the cavity. There is an additional barrel rail as part of the propulsion bus-aft shunt circuit means locate proximal and parallel the power rail at the shunt edge of the armature and insulated therefrom. With an armature for the device in the barrel cavity forward wall conductor of the wall conductor assembly is the group of one or more consecutive wall conductors immediately in front of the armature propulsion bus with continuous electrical continuity with the armature forward current shunt and continuous sliding electrical continuity with said shunt at any instant during armature movement in

the barrel cavity. Aft wall conductor of the wall conductor assembly is the group of one or more consecutive wall conductors immediately aft the armature propulsion bus with continuous electrical continuity with the armature aft current shunt and continuous sliding electrical continuity with said shunt at any instant during armature movement in the barrel cavity. With power supplied to the device the electric current direction forward wall conductor of the wall assembly in the same direction as the propulsion bus electric current direction and the magnetic fields of the forward wall conductor electric current interact with the electric current in the armature propulsion bus creating forces therein attracting the propulsion bus towards forward wall conductor. Major components of said forces are barrel cavity axis parallel and muzzle directed. The magnetic fields of the electric current in ast wall conductor interacts with the electric current in the armature propulsion bus creating forces therein repelling the propulsion bus from aft wall conductor. Major components of said forces are barrel cavity axis parallel and muzzle directed. The electric current flow in the wall assembly barrel bus is in the same direction as the current direction in its proximal barrel power rail and the electric current in said third rail

part of the propulsion bus-aft shunt circuit means is in the same direction as the electric current in the proximal barrel power rail. Said power rail electric current are oppositely directed and parallel the cavity central axis. The magnetic fields of the current flow in the power rail proximal the wall conductor assembly barrel bus and in said barrel bus along with the magnetic fields of the electric current in the power rail distal the barrel bus and the barrel rail of the propulsion bus-aft shunt circuit means interact with the electric current in armature propulsion bus as in a conventional rail gun creating forces therein with cavity axis parallel muzzle directed components. A generalized equation for the forces in this design is:

$$3) \quad \text{Force} = [2 + 2(.9)] \int_{r_0}^{r_2} I\,dr \times \mu_o I/(2\pi r) + 2[(.9) \int_{L_0}^{L_1} I\,dl \times \mu_o I \cos \alpha/(2\pi d)].$$

[0065] The first integral expression is for the rail gun type propulsion forces with the 2(.9) term of the coefficient compensates for the displacement of the barrel bus and propulsion bus-aft shunt circuit barrel rail centers from the mid line of the propulsion bus. The second integral expression is a combined approximation of the combined forces attributed to forward and aft wall conductor and the Cos alpha /(2pi d) factor has a mean value acquired by

computer iteration and is dependant of the physical dimension of a particular design and the number of complete wall conductors with shunt electrical continuity at any instant and their distribution. The dl limits and are the ends of the minimum common length of the parallel wall conductor and propulsion bus and the length ($L_1 - L_0$) of only importance regardless the source. propulsion bus or wall conductor of the individual term. A second component of the wall conductor induced force on the armature propulsion bus in the topic design is directed towards the wall assembly by forward wall conductors and away from the assembly by aft wall conductors and manifests itself as an oscillating force orthogonal the propulsion bus and cavity axis and/or couple about the propulsion bus and its generalized expression of value is:

[0066]

$$4) \qquad \text{Force}_{\perp} = 2\left[(.9) \int_{L_0}^{L_1} I\, dl \times \mu_o\, I \operatorname{Sin} \alpha / (2\pi d) \right].$$

[0067] A design of the device a cylindrical cavity and armatures, and one wall conductor assembly, and with a propulsion bus-aft shunt circuit means also utilizing a barrel rail proximal the power rail distal the barrel bus is illustrated in figure 10 through 13. In this particular design the propulsion bus is a cylindrical band close to the armature

cylindrical surface proximal the armature surface with the wall assembly. A generalized equation for the forces in this design is:

[0068]

$$5)\qquad \text{Force} = [2 + 2(.9)]\int_{r_0}^{r_2} I\,dr \times \mu_o I/(2\pi r) + 2[(.9)\int_{\theta_0}^{\theta_1} I\,r_b \cdot d\theta \times \mu_o I \cos\alpha/(2\pi d)].$$

[0069] The first integral term is the force attributed to the barrel rails and the second is the force attributed to the wall conductors, where r_b is the propulsion bus radius and is the common length of the propulsion bus to forward and aft wall conductors; i.e. the length of the propulsion bus in which its electric current is effected by the magnetic fields of the electric current in said wall conductor.

[0070] This design also suffers from the orthogonal forces and couples similar those in the first design and given by the generalized expression:

$$6)\qquad \text{Force}_{\perp} = 2[(.9)\int_{\theta_0}^{\theta_1} I\,r_b \cdot d\theta \times \mu_o I \sin\alpha/(2\pi d)]\sin\theta .$$

[0071] When $(L_1 - L_0)$ in 4 above equals $(\theta_1 - \theta_0)\,r_b$ in 6, the force values of equation 6 are $2/\pi$ those of equation 4.

[0072] Another embodiment of the invention illustrated in figures 14 through 18 uses only forward and aft wall conductor to effect armature propulsion in the barrel cavity. Its propulsion bus extends through nearly the entire perimeter of

the armature at the armature surface proximal the barrel cavity wall and wall conductors therein. Armatures with odd shaped right cross sections are accommodated by this design which also permits armatures with very long propulsion bus. As the propulsion bus current path starting point and end point through the magnetic fields of the barrel rails and wall assembly barrel bus are proximal each other forces in the propulsion bus due said barrel rails and bus are negligible; i.e. the first integral term in equation 3 above disappears. Forces orthogonal the propulsion bus and barrel cavity axis largely cancel each other; i.e. equation 4 disappears.

[0073] To negate the orthogonal forces of the design in figures 4 through 9 a second wall conductor assembly in the second barrel wall segment is added and said forces attributed to one wall conductor assembly are cancelled by like force oppositely directed attributed to the second wall conductor assembly. See figures 19 through 23. For clarity the barrel wall segment and wall conductor assembly therein along with the armature side closest the electrical continuity between the forward current shunt and its proximal power rail are indicated as 'first'; e.g. first armature side, first wall conductor assembly, etc.. and the

equivalent elements on the second side of the armature are indicated as 'second'; e.g. second armature side, forward current shunt surface in the second armature side, etc.. The forward and aft armature current shunt each have a first and second armature side surface in the first and second armature sides, respectively. With an armature in the barrel cavity, the first and second surfaces of its forward and aft current shunt have electrical continuity with the contact means of forward and aft wall conductor of the first and second wall conductor assembles, respectively. The topic design also uses a barrel rail as an element of the propulsion bus-aft shunt circuit means. The wall assembles in the circuit of the design are in parallel. Depending on power rail polarity, the armature forward current shunt distributes the electric current arriving equally to the first and second wall conductor assembles via their forward wall conductor or combines the electric currents arriving from said forward wall conductor when rail polarity is reversed. The aft wall conductor combines the currents arriving from said aft wall conductor of the first and second wall conductor assembles or with power rail polarity reversed the aft wall conductor equally distributes the current to the first and second wall conductor

assembly via their respective aft wall conductor. The generalized force equation for this design is also equation 3 above. In the electric circuit for this arrangement the wall conductor assembles and their resistance are in parallel.

[0074] With propulsion bus-aft shunt circuit means of the invention a current bus located in the armature as in figures 24 through 26, all but small currents creates formidable forces of attraction on said bus towards the proximal barrel rails. The armature shown will work in the first and last designs discussed above in these cases the third rail becomes a passive structure element and the armature current shunt surfaces in the armature second side in the first design are also passive. However, when two devices of the invention that have armature current bus as their propulsion bus-aft shunt circuit means are combined with one device the mirror image of the second about a plane proximal the power rail centerline at the barrel bus and parallel the cavity axis and perpendicular the wall conductors as shown in figure 26 this problem is eliminated. The armature bus force in one armature segment is oppositely directed the armature bus force in the second. The magnetic fields due to the like polarity power rails at the extreme cavity edges are attenuated about a third in

strength in this design.

[0075] One design of the invention with 2 wall conductor assembles electrically connected in series via aft shunt-forward shunt circuit is illustrated in figures 27 through figure 36. The armature has individual forward and aft current shunts means in its first and second side; i.e. the first forward current shunt and first aft current shunt are in the first side of the armature and a second forward current shunt and second aft current shunt are in the second side of the armature.

[0076] In the topic design one barrel rail proximal the power rail distal the barrel bus is, with its continuous electrical continuity with surfaces of the first aft armature current shunt and second forward current shunt, said aft shunt-forward shunt circuit means. Another barrel rail proximal said barrel rails; i.e. the power rail and proximal third rail, and its continuous electrical continuity with surfaces on the second aft current shunt and armature propulsion bus is the propulsion bus-aft shunt circuit means in the design.

[0077] With an armature for the device in the barrel cavity and the positive barrel power rail proximal the third rail and fourth rial, the electric current supplied to the positive rail by an external power supply is wrapped around three

sides of the first armature side, by the first wall conductor assembly. The electric current then passes via an aft shunt-forward shunt circuit mean to the second wall conductor assembly to the second wall conductor assembly wherein the current circulates on three sides of the second armature side before exiting via armature second aft current shunt to the fourth rial. The fourth rail supplies current to the armature propulsion bus via continuous sliding continuity therewith and the armature propulsion buss current returns to the power supply via its continuous sliding continuity with the return power rail.

[0078] Current shunts on the armature coacting with the positive power rail, the third rail, the propulsion bus and with conducting elements in the rail gun barrel, enable the current path from the positive power rail, through the armature propulsion bus to the negative or output rail and there from to the return terminal of the power supply. The magnetic field density acting on the armature current path is increased by said path and the current required to achieve a desired armature accelerating force is thereby reduced.

[0079] During the topic invention operation, the magnetic fields of the electric current in forward wall conductor of both

first and second wall conductor assembles during the armature barrel cavity traverse interacts with the armature propulsion bus current creating forces of attraction to said conductors on the armature propulsion bus, with muzzle directed components. The magnetic fields of the electric currents in aft wall conductor of said wall conductor assembles interacts with the propulsion bus electric current creating forces of repulsion by aft wall conductor on the armature propulsion bus with muzzle directed components. Therefore, both sets of magnetic fields add to the force accelerating the armature from breach to muzzle in the rail gun. The magnetic fields due to the current passing through the wall assembles barrel buses, the barrel rail of the propulsion bus-aft shunt means, the barrel rail of the aft shunt-forward shunt circuit means, and the two barrel power rails also interact with the armature propulsion bus current creating six additional forces on the armature with muzzle directed components. Four or five forces of the six are somewhat diminished in magnitude from the forces on the armature resultant the power rail magnetic fields. This reduction is caused by the displacement of the center lines of barrel buses and two or all three of the armature shunt proximal barrel rails;

i.e. the two circuit means barrel rails and the barrel power rail, from the center line plane generated by the center line of the current flow in an armature traversing the barrel cavity . These additional forces in a rail gun of the invention comprise an enhancement of rail gun forces .

[0080] When one or both the aft shunt-forward shunt circuit means and propulsion bus-aft shunt are in an armature with barrel axis parallel direction, large lateral forces driving the armature towards the rails are created by the proximate barrel rail(s) currents magnetic fields interacting with said armature current pathways resulting in frictional forces on the armature which must be overcome. Alternatively, a tandem device arrangement as discussed above will neutralize said forces. There are no such pathways in the topic design.

[0081] Looking to the design in figures 37 through 41 the force on the armature due to the magnetic fields of the current in the two power rails, the two barrel rails for said circuit means, the barrel bus(es), forward and aft wall conductor in a cylindrical barrel cavity rail gun of the invention can be roughly approximated by:

[0082]

$$7)\quad \text{Force} = [2 + 2(.90) + 2(.80)] \int_{r_0}^{r_2} I\,dr \times \mu_o I/(2\pi r) + 4[(.9) \int_{\theta_0}^{\theta_1} (I/2)\, r_b\, d\theta \times \mu_o I \cos\alpha/(2\pi d)].$$

[0083] The adjustment terms in the parenthetic coefficient of the first integral term above are required by rails and wall buses center lines displacement from the plane generated of the propulsion bus current flow centerline during armature barrel cavity traverse. More complete force approximation would have the first integral and its coefficients and limits replaced by six integrals with the same integrand but distinct coefficients and limits.

[0084] The adjustment term in the parenthetic coefficient of the second integral is a general compensation term which would be removed when the integral is replace by four separate integrals with similar limits but with the (COS α)/d value of the integrand term μ_o [I/(2πd)] COS α uniquely approximated by computer iteration for each forward and aft wall conductors variation in current and orientation relative the propulsion bus during armature traverse of the barrel cavity and the mean value of the approximations used.

[0085] In the above equation, r_a is the distance from the electrical center of one power rail to the armature sliding abutment of the second, r_o is the radius from the electrical center line of a rail to its sliding contact with the armature, r_b = bore/2, 'd' is the mean distance between the forward and

aft wall conductors and the armature propulsion bus and angle alpha is the angle of distance 'd' with the barrel cavity axis.

[0086] Using the above force equation with $r_a/r_o = 5.4$, a current of approximately 78,087 A with a potential between the rails of approximately 120.5 volts is required to attain the performance of the 11.43 mm (.45 in) gun discussed above. A significant current reduction from that required by a conventional rail gun.

[0087] The force for a Fauchon-Villeplee type rail gun of the invention for rectangular, disk or knife blade armatures and without external magnetic field sources can be approximated by:

$$8)\quad \text{Force} = [\,2 + 2(.90) + 2(.80)\,]\int_{r_o}^{r_a} I\,dr \times \mu_o\, I/(2\pi r) \;+\; 4[(.9)\int_{L_o}^{L_1} I\,dl \times \mu_o\, I\,\mathrm{Cos}\,\alpha/(2\pi d)\,].$$

[0088] Using the above approximating force equation, with $r_a / r_o = 15$, a current of 42493 Amp a t 221.4 Volt is required to accelerate a 6.48 gram (100 grain) flat projectile with a propulsion bus length of 0.0422 m (1.66 in.) to 1524 m/s (5000 ft/s) in a 0.6264 m (24 in.) barrel.

[0089] When the barrel rail and other elements of the propulsion bus-aft shunt circuit means of the invention is replaced by a very short armature current bus connecting the second

aft current shunt directly to the propulsion bus in the above armature, the magnetic fields of the proximal barrel wall rail currents interact with the current in said bus creating large forces of attraction on said bus (i.e. forces lateral to the direction of barrel cavity traverse by the armature) and subsequent frictional loses. For example, when said bus is located 0.003175 m (1/8 in.) from proximal barrel wall rails and carries approximately 44,284 Amp, the force of attraction of the topic 6.48 gram projectile to the barrel wall is between 6227.5 Newton (1400 lbf) and 9786 Newton (2200 lbf).

[0090] As discussed above loads of this nature might be negated by tandem barrel cavity-tandem armature arrangements as in figure 25,26, 42 and 43, where the attractive force between the rails and proximal parallel current paths in the armature are resolved as tinsel stress in the tandem armature. When a spin is to be imparted to an armature traversing the barrel cavity the barrel and all elements in its wall have a constant angular displacement at their radius to the barrel cavity axis per unite cavity axis distance or twist about the cavity axis. The armature and all elements therein have like twist. Figure 44 illustrates the twist of a barrel with a cylindrical cavity.

[0091] Whether by design or unavoidable, when an arc between the power rails develops behind the armature of the invention, it will be confined to the space immediately behind the armature propulsion bus rather then extend through the entire barrel cavity region behind the armature. This is the effect of the forces imposed on the arc current by the magnetic fields of the currents in aft wall conductor.

[0092] Wall conductors beyond their common barrel bus are isolated from one another throughout their length. The wall conductors isolation can be by barrel material, or insulating coating or sleeves, or less preferably by clearance gaps(air). There can be one wall conductor, or the equivalent sum in cross section areas to one wall conductor, in contact with the forward or aft armature current shunts, or many. When there are many conductors interacting with the shunts, their combined resistance and induction are calculated using formulae for parallel arrangements.

[0093] Additionally, although the wall conductors for devices illustrated herein have constant cross section areas, in applications where barrel mass is an important constraint, the cross section area of wall conductors at the barrel breach, where the conduction time interval of wall con-

ductors is many times the conduction time interval of wall conductors located near the muzzle, will be larger then the cross section areas of wall conductors at the muzzle. Additionally the wall conductors near the breach might be closer together while still parallel and insulated from each other; i.e. the wall conductors would no longer have uniform distribution along their common barrel buss.

[0094] For clarity of presentation, the invention embodiments portrayed in the following illustrations are chemically bonded together in assembly. In practical application and for quick refurbishment or repair, the barrel would be assembled using mechanical fastening means well know in the art. Molding methods well know in the art can be used for armature fabrication. For the flat projectiles of the last example, the propulsion bus and current shunts whose operation life is measured in fractions of a millisecond are simple formed pieces of sheet metal Aluminum or Copper, mass restriction permitting, or other good conductor. As a safety measure the propulsion bus should after the anticipated barrel cavity traverse time melt or burst open from heat build up.

[0095] Voids and masses necessary to locate the armature center of mass for in flight stability are not shown in the follow-

ing figures. The armatures for the invention and the barrel of the invention are made of non-conducting ceramic material such as SiC or a high strength proprietary plastic material. The wall conductor assembles and rails of the barrel are made of good conducting material such as copper or aluminum alloys. Conducting elements in armatures of the invention are made of good conducting material such as aluminum alloys. The insulating SiC and plastic structure of the barrel and armatures of the invention can also be made of a conducting metal such as Aluminum as long as effective electrical insulation is used to isolate the conducting elements of the invention from those intended to be non-conducting. If structure metal is used proximal the wall conductors, it should be as magnetically neutral as possible. The wall conductors experience rapid field reversal.

[0096] Generally in regards to the various embodiments of the invention, surfaces of elements of the invention with sliding continuity with other elements thereof might be treated and/or machined and/or formed to effect a smooth more effective sliding continuity; e.g. a surface with boundary edges rounded and surface treated with low friction conducting substances and/or textured to as-

sure a correct current path when elevated voltages are extant in the invention. The armature may have variation in its surface extruded in the direction of its cavity traverse; e.g. corrugated surface with troughs parallel the barrel cavity axis. The barrel and its cavity may extend at the muzzle and/or breach beyond the electromotive propulsion elements of the invention and in said extensions the armature may or may not be acted on by additional motive, orientation, material modifying or other devices not part of the invention; i.e. the invention may share a common barrel and barrel cavity with other devices not necessary to the invention.

[0097] TERMINOLOGY

[0098] AFT WALL CONDUCTOR: With an armature for the device in the barrel cavity, the aft wall conductor is the group of one or more consecutive wall assembly wall conductors which have continuous electrical continuity via their contact means with an aft current shunt surface at said contact means location in the barrel cavity and during armature movement in the barrel cavity, aft wall conductor is the group of one or more said wall conductors which have via their contact means continuous sliding electrical continuity with said aft shunt surface at said contact means

barrel cavity location at any instant during said movement. Alternatively, aft wall conductor is the group of one or more consecutive wall conductors with contact means having continuous electrical continuity with surface of an aft armature current shunt located at the barrel cavity location of said contact means and during armature movement in the barrel cavity said contact means have continuous sliding electrical continuity with surface of an aft armature current shunt sliding through said contact means barrel cavity location.

[0099] ARMATURE: The armature is herein illustrated as an single use element of the invention; however, this limitation to use of the claimed devices is not intended. Although the armature of the device may be used as the projectile in a modified rail gun or platform for accelerating a projectile in such a platform, alternative uses might also include reusable transport propulsion means wherein the armature of th invention is constructed as reusable carriage of a transport system utilizing the claimed invention at least partially for propulsion and in which the barrel, barrel cavity, etc. might have turns of various radius and the armature carriage of the system is formed or deformable to negotiate said turns.

[0100] ARMATURE CENTRAL AXIS: The armature central axis is the line through the area centroid centers of right sections of that portion of the armature in the barrel cavity which has right sections identical in shape as the barrel cavity right sections but slightly undersized thereof. The armature central axis in the barrel cavity is parallel and closely proximal the barrel cavity central axis or coincident said axis.

[0101] BARREL AND BARREL CAVITY: The barrel and barrel cavity is that section of a barrel and barrel cavity in which the barrel rails and wall assembly are extant; i.e. where barrel elements of the invention are extant. Barrel and barrel cavity means also a continuous barrel section which contains the calmed device and which may have sections before and /or after the barrel section with the invention with functions outside those of the calmed device. e.g. sections in front of the breach end of the 'barrel' might: be a simple fixed or expendable cap closing the breach end of the cavity, or be part of an rapid breach load mechanism, mount expendable pneumatic armature injection cartridge, or armature injection means in an expendable cartridge using the invention to inject the armature into the cavity, and/ or may add or modify propellant

or explosive payload or a guidance system of the armature, and barrel sections after the 'barrel muzzle' of the invention may :be a simple frangible end cap protection from the elements, initiate chemical propulsion of the armature, or include other electromagnetic propulsion means and/or initiate safe- unsafe trigger mechanisms for explosive payload of the armature.

[0102] BARREL BUS AND RAIL LENGTH AND LOCATION: Barrel rails; i.e. the two power rails, the barrel rail of a propulsion bus-aft shunt circuit means and barrel rail of a aft shunt-forward shunt circuit means, length and location along the barrel cavity length might vary slightly from one another in a design. Therefore, the spacial and size relationships between the barrel rails herein are described using the terms "like or similar"; i.e. the barrel rail length is like or similar the length the proximal power rail and it has a like or similar location along the barrel length.

[0103] For example, the power rail with continuity with an armature forward current shunt might at the breach be shortened or displaced in the muzzle direction by the distance from the breach proximal edge of an armature aft current shunt edge to the breach proximal edge of an armature forward current shunt, the power rail with propulsion bus

continuity might be shortened or displaced in the muzzle direction the distance from the breach proximal edge of the aft current shunt to the breach proximal edge of the armature surface with said power rail continuity, the barrel rail of a propulsion bus-aft shunt circuit means might be shortened at the muzzle by the distance between the muzzle edge of the forward current shunt and muzzle edge of said propulsion bus surface. When an aft shunt-forward shunt circuit means included a barrel rail, the length of said rail is the length of the barrel cavity wherein the invention exist.

[0104] Barrel bus length and location along the barrel cavity length might vary slightly, from proximal barrel rails; therefore, "like or similar" is used to reference the length and location of a wall conductor assembly barrel bus to a barrel rail; e.g. when a barrel rail for a aft shunt-forward shunt circuit means is extant the barrel bus length should be at least as long as said barrel rail, and the interval and location of the barrel cavity length of barrel bus should be identical or include that of said barrel rail. Other possible variation will be apparent to practitioners of the relevant arts.

[0105] BARREL RAIL: A barrel rail is a conductor in the barrel cav-

ity wall, which is parallel the cavity central axis or has a twist at constant radius about said axis, extends the length of the barrel of the invention and has barrel cavity surface its length which has electrical continuity with an element or elements of an armature in the barrel cavity.

[0106] CAVITY CENTRAL AXIS: The cavity central axis is the line through all barrel cavity right section area centroid centers.

[0107] ELECTRICAL ISOLATION: An element that is electrically isolated or an isolated element is limited in meaning to lacking low resistance electrical paths to or through its neighbors. Magnetic and electric fields couplings are ignored.

[0108] FIRST ARMATURE SIDE: The first armature side is the armature side with the first forward current shunt or the side of the armature proximal the barrel power rail proximal the armature current shunts.

[0109] FIRST CAVITY WALL SEGMENT: The first cavity wall segment is the cavity wall proximal the first armature side and also contains the first wall conductor assembly.

[0110] FIRST FORWARD CURRENT SHUNT: The first forward current shunt is the armature forward current shunt with continuous continuity the proximal barrel power rail.

[0111] FIRST AFT CURRENT SHUNT: The first aft current shunt is the armature aft current shunt in the first armature side.

[0112] FIRST WALL CONDUCTOR ASSEMBLY: The first wall conductor assembly is the wall conductor assembly in the barrel cavity wall proximal the first armature side.

[0113] FORWARD WALL CONDUCTOR: With an armature for the device in the barrel cavity, the forward wall conductor is the group of one or more consecutive wall assembly wall conductors which have continuous electrical continuity via their contact means with a forward current shunt surface at said contact means location in the barrel cavity and during armature movement in the barrel cavity, forward wall conductor is the group of one or more said wall conductors which have via their contact means, continuous sliding electrical continuity with said forward shunt surface at said contact means barrel cavity location at any instant during said movement. Alternatively, forward wall conductor is the group of one or more consecutive wall conductors with contact means having continuous electrical continuity with surface of an forward armature current shunt located at the barrel cavity location of said contact means and during armature movement in the barrel cavity said contact means have continuous sliding electrical con-

tinuity with surface of a forward armature current shunt sliding through said contact means barrel cavity location.

[0114] POWER RAIL: A power rail is a barrel rail which has connection means at its end for attachment of outside circuit means from a terminal of an outside power supply which supplies the electric power required for operation of the claimed device.

[0115] ROTARY ELECTRIC MOTOR APPLICATION: When the breach end of a barrel cavity axis in a plane is made continuous with its muzzle end; i.e. when the barrel cavity axis is a circle, and wall conductor assemble is in a cylinder wall about said circle center, and the armature is a cylinder wall with propulsion bus occupying the barrel cavity about said circle center mounted for relative rotation with said wall assembly cylindrical wall the electromotive propulsion of the claimed devices may be applied as a rotary motor and other elements of the currently claimed device find respective location and function therein.

[0116] SECOND ARMATURE SIDE: The second armature side is the armature side without the first forward current shunt.

[0117] SECOND CAVITY WALL SEGMENT: The second cavity wall segment is the cavity wall proximal the second armature side and also contains the second wall conductor assem-

bly.

[0118] SECOND FORWARD CURRENT SHUNT: The second forward current shunt is the armature forward current shunt in the second armature side with continuous continuity the aft shunt-forward shunt circuit means.

[0119] SECOND AFT CURRENT SHUNT: The second aft current shunt is the armature aft current shunt in the second armature side and the second aft current shunt has continuity with the propulsion bus via the propulsion bus-aft shunt circuit means.

[0120] SECOND WALL CONDUCTOR ASSEMBLY: The second wall conductor assembly is the wall conductor assembly in the second barrel cavity wall segment.

[0121] TWIST

[0122] A Barrel Cavity with twist has consecutive right sections to the barrel cavity central axis taken at equally spaced distances from each other along the barrel cavity axis from breach to muzzle with identical areas and shapes which have a constant increasing angular displacement, angle/distance, about the cavity central axis from breach to muzzle.

[0123] An Armature with twist for use in a barrel of the invention with twist has consecutive right sections taken to its cen-

tral axis at equally spaced distances from the armature breach end to muzzle end which have a constant increasing angular displacement, angle/distance, about the armature central axis and said constant increasing angular displacement is identical that of said barrel cavity. All structures of elements in an armature with twist also have identical twist at their armature locations so as to function properly when in the barrel cavity with the twist.

[0124] Barrel Rails and Barrel Bus twist in barrels with a twist have twist or angular displacement per unit cavity axis distance about cavity central axis identical the barrel cavity twist but at a fixed radius which is the perpendicular distance measured at any point of the cavity central axis to said rail or bus.

[0125] The following drawings illustrate embodiments of the invention, and are not intended to limit the scope of the invention. Figures 1 through 3 illustrate examples of prior art.

[0126] Figure 1 of the drawings portrays the basic arrangement of elements of a simple prior art rail gun. Shown are positive current input power rails 1, and the return current power rail 3. Located between power rails 1 and 3 is current conducting armature 2. The rail gun current path is

power rial 1, armature 2, power rail 3. The magnetic fields, H, inherent the current flow in rails 1 and 2 are indicated. These fields interact with the current passing through the armature, creating an electromotive force accelerating the armature in the indicated direction. The magnetic fields of each rail also interacts with the current flow in the other rail imposing a force on that rail directed to increase the distance between the rails. These forces impose significant radially directed stresses on the rail gun barrel.

[0127] Drawing Figure 2 portrays a coaxial or monopole rail gun of the prior art. The single rail 1 is in the cylindrical bore axis and the return current path is via the cylindrical conductor 3, inclosing rail 1. The rail gun cylindrical armature 5 in cylinder 3 is of a size permitting continuous sliding electrical contact with cylinder 3 wall. Through armature 5 and coincident with its cylindrical axis is a cylindrical bore through which rail 1 extends with continuous sliding electrical contact. The path of current in the gun is up rail 1, through the armature 5 radially to the conducting cylinder wall 3. The single magnetic field Hr due to the current in the central rail 1, interacts with the radially flowing current of the armature creating an electromotive force on

the armature directed axially in the cylinder. It should be pointed out that by making conductive only an axial extending element of the cylinder 3 of small angular extent [i.e. radius, r, times small angular increment] a second magnetic field equal in magnitude Hr above would be extant. In this case the armature current would be between the central rail 1 and the conducting element in the cylindrical surface 3; i.e. a second rail, and a force on the armature twice that experienced in the single field arrangement would be extant. Also shown in figure 2 are electrical coil 6 in insulating sleeve 7 which is an extension of the conducting cylindrical sleeve 3. Current through coil 6 has a magnetic field Ha which extends axially inside the cylinder. Field Ha interacts with the radially directed current in the armature creating a rotational moment in armature 5 for improved armature flight characteristics.

[0128] Drawing figure 3 is a simplified portrayal of a Fauchon-Villeplee rail gun. Shown are power rails 1 and 3 and the armature, 5 extending between. Armature 5, a ridged rectangular sheet of conductor in the instant example, has mating sliding continuous electrical contact with slots in the power rails 1 and 3 as shown. Shown also are electromagnetic coils 6 and 6a positioned perpendicular to and

on opposite sides of the plane of armature travel. The coils, 6 and 6a, have fields which are complementary to each other and interact with the current flowing through the armature, 5, creating an armature accelerating force. Said armature force is adjustable by variation of the coils magnetic fields, Ha, and the coil field, Ha, strength is proportional to the adjustable coil current. The force on the armature due to the coil fields can be many times larger then the force on the armature due to the rail current magnetic fields. The coil currents and therefore their field strengths Ha are independent of the armature accelerating magnetic fields resultant the rail current. Although the electromagnetic coils shown, 6 and 6a are air core, they could have solid cores or iron, steel or other material or be replaced altogether by permanent magnets and their fields.

[0129] Figure 4 through 9 portray a simple design of the invention with a thin rectangular barrel cavity and armatures, a single wall conductor assembly, and a barrel rail, in addition to the two power rails, used in the propulsion bus-aft shunt circuit means.

[0130] Figure 4 is a cutaway portrayal of the invention 10, with two barrel sections 11 and 11a and barrel cavity 33 in

which armature 32 is located. Barrel cavity 33 extends into the barrel power rail 26 open channel 27 and the surfaces of said rail which enclose the cavity are cavity surfaces of the rail. At the opposite edge of the cavity is shown barrel rail subassembly 25 in which barrel power rail 29 and propulsion bus-aft shunt circuit means barrel rail 1 is located. Shown in subassembly 25 is open channel 47 also part of the barrel cavity 33, bounded on one side by surface 2, the continuous cavity surface of barrel rail 1, and on the other side by surface 30 (see figure 8), the continuous barrel cavity surface of barrel power rail 29. Guide 45 of armature 32 is in and travels in open channel 47. And surfaces of forward armature current shunt 34 and aft armature current shunt 37 have continuous electrical continuity with barrel rail surfaces 30 and 2 therein, respectively, and said continuity is siding with armature movement in the barrel cavity. Also shown is the leading edge, 43, of armature 32. Connection lugs 28 and 31 of barrel power rails 26 and 29, respectively, are shown at the breach end of the barrel where they are connected by circuitry outside the invention to a power supply outside the invention. The single wall conductor assembly 16, its barrel bus 17 and the plurality of parallel

wall conductors which are uniformly distributed along the length of the barrel bus are indicated. The plurality of uniformly distributed wall conductors 18 are physically and electrically continuous with barrel bus 17 at one end and extend to close proximity the barrel rail subassembly 25 in the cavity wall close to or at the cavity surface 20.

[0131] Figure 5 is a view of the assembly in figure 4 disassembled. Shown are casing section 11, wall conductor assembly 16 with barrel bus 17 and wall conductors 18 uniformly distributed along the barrel bus and extending perpendicular therefrom. Also indicated at the end barrel bus distal end of the wall conductor is contact means 19. Cavity liner 20 is illustrated with the plurality of openings 21 each giving a wall conductor contact means 19 access to the barrel cavity 33. Barrel rail subassembly 25 is shown with barrel power rail 29 and propulsion bus-aft shunt barrel rail displaced therefrom in the illustration. Armature 32 with guide 46 which with the armature in the cavity is in open channel 27 of barrel power rail 26. Connection lug 28 extend to outside the body of the device through channel 14 in casing section 11a.

[0132] Figure 6 is a view of an assembled armature 32 for the design in figure 4. Shown are armature edge 43 which in

the barrel cavity is the armature leading edge and edge 44 the armature breach directed edge. Armature guide 46 which in the assembly is in barrel rail 26 open channel 27. Armature guide 46 has propulsion bus 41 extending through it with surface 42 which when located in the barrel rail 26 open channel 27 has continuous electrical continuity with the surfaces thereof and with armature movement in the barrel cavity said continuity is sliding. In the assembly, armature guide 45 is in barrel rail subassembly 25 open channel 47 and therein surface 36 of forward armature current shunt 34 has continuous electrical continuity with surface 30 of barrel power rail 29 and propulsion bus 41 surface 40 has continuous electrical continuity with surface 2 of barrel rail 1 and surface 39 of aft armature current shunt 37 has continuous electrical continuity with surface 2 of barrel rail 1 and said continuity are sliding during armature movement in the barrel cavity 33. Barrel rail 1 with its above noted continuities constitute the propulsion bus-aft shunt circuit means. Also indicated are cap 53 with guide 45. End cap 53 is structurally integral the assembled armature 32.

[0133] Figure 7 is a portrayal of the armature in figure 6 disassembled. Shown are end cap 53 of armature assembly 32

and armature guide 45 thereon. End cap 53 with guide 45 has relief 52b which with relief 52 in the armature body mounts aft armature current shunt 37 and surface 39 of said shunt in said relief, when in the barrel cavity has electrical continuity with barrel rail 1. Propulsion bus 41 mounts with surface 40 in relief 54b in end cap 53 and guide 45 and extends through the armature in channel 54 and its surfaces 42 and 42a are at armature guide 46 where, with the armature in the barrel cavity, they have continuous electrical continuity with barrel cavity surfaces of channel 27 of power rail 26. End cap 53 with guide 45 has relief 50b which with relief 50 in the armature body mounts forward armature current shunt 34 with surface 36 in relief 50b wherein, with the armature in the barrel cavity said surface has continuous electrical continuity with the cavity surface 30 of barrel power rail 29. With armature movement in the barrel cavity said continuous electrical continuities are sliding continuous electrical continuities. Also shown in the figure are edge 44 which in the barrel cavity is located towards the breach end of the cavity.

[0134] Figure 8 portrays a section of the breach end of the barrel rail subassembly 25. Shown are power rail 29, its barrel

cavity surface 30 and its power connection lug 31. Barrel rail 1 is the rail portion of the propulsion bus-aft shunt circuit means and open channel 47 of subassembly 25 is between its rail 1 surface 2 and rail 29 surface 30 both of which are the respective rails continuous barrel cavity surfaces.

[0135] Figure 9 is a cutaway oblique view of the electromagnetic propulsion device in figure 4 wherein most of the barrel walls and liner have been removed and barrel rail subassembly 25, the barrel, barrel rails 1 and 29, armature 32, armature guide 45 in open channel 47 of assembly 25 and barrel power rail 26 cutaway to illustrate the electric current path in the device when barrel rail 29 is the positive barrel power rail; i.e barrel rail 29 via its connection lug 31 is connected to the positive terminal of an outside power supply via circuitry external the device. Consecutive points along the current pathway are indicated by italicized letters, a, b, c, d, e, f, g, h, I, j, k, l.

[0136] Beginning at the breach end of the barrel and barrel power rail 29, 'a' in the path, electric current in barrel rail 29 is towards the barrel muzzle toward point 'b' and the magnetic fields of said current interact with the electric current in the armature propulsion bus 41 creating forces

therein with barrel cavity axis parallel muzzle directed components. Point 'b' is surface 36 of forward armature current shunt 34. With an armature of the device in the barrel cavity forward armature current shunt 34 has, via its surface 36 continuous electrical continuity with surface 30 of power rail 29, continuous electrical continuity barrel rail 29. With barrel movement in the armature said continuous continuity is sliding. The electric current passes from surface 36, point 'b', to surface 35, point 'c', in forward armature current shunt 34. The electric current passes from forward current shunt surface 35 to forward wall conductor, point 'd', of the wall assembly 16 wall conductors 18 via contact means 19 at the shunt surface 35. With the armature in the cavity, forward wall conductor is the group of one or more consecutive wall conductors 18 of the wall conductor assembly 17 that have contact means 19 at shunt surface 35 location in the barrel cavity and there is continuous electrical continuity there between. During armature movement in the barrel cavity said continuity is continuous sliding electrical continuity. The direction of electric current in forward wall is towards wall assembly 16 barrel bus 17; from point 'd' to 'e', and the magnetic fields of the electric current in forward wall con-

ductor interacts with the electric current in the armature propulsion bus 41 creating forces therein with barrel cavity axis parallel muzzle directed components. Electric currents in forward wall conductor and the armature propulsion bus are parallel and like directed and the forces created in the propulsion bus by the forward wall conductor magnetic fields appear as forces of attraction there between. The electric current exits forward wall conductor to the wall assembly 16 barrel bus 17 with breach direction in said bus; i.e. from 'e' to 'f' direction. The magnetic fields of said barrel bus electric current interacts with the electric current in the armature propulsion bus 41 creating forces therein with cavity axis parallel muzzle directed components. The electric current exits wall conductor assembly 16 barrel bus 17 to aft wall conductor of said assembly wall conductors 18 with direction therein towards the barrel rail assembly 25; i.e. 'f' to 'g' direction. With the armature in the cavity, aft wall conductor is the group of one or more consecutive wall conductors 18 of the wall conductor assembly 17 that have contact means 19 at aft armature current shunt 37 surface 38 location in the barrel cavity and there is continuous electrical continuity there between. During armature movement in the barrel

cavity said continuity is continuous sliding electrical continuity. The magnetic fields of the electric current in aft wall conductor interact with the armature propulsion bus 41 electric currents creating therein forces with barrel axis parallel muzzle directed components. Electric current in aft wall conductor and the armature propulsion bus are parallel and oppositely directed and the said forces created in the propulsion bus by the aft wall conductor magnetic fields appear as forces of repulsion there between. The electric current exits aft wall conductor via contact means 19 , 'g', to surface 38 ,'h', of the aft armature current shunt 27. The electric current exits aft armature current shunt 37 to barrel rail 1 at aft current shunt 37 extension with surface 39 in the barrel rail assembly 25 open channel 47 via the continuous electrical continuity therein between shunt surface 39 and barrel rail 1 surface 2; i.e. from 'h' to 'i'. With armature movement in the barrel cavity 33 said continuity is continuous sliding electrical continuity. Electric current direction in barrel rail 1 is towards the muzzle; i.e. from 'i' to 'j'. The magnetic fields of barrel rail 1 electric current interact with the armature propulsion bus current creating forces therein that have cavity axis parallel muzzle directed components. Electric

current continues from barrel rail 1 to armature propulsion bus 41 via the continuous electrical continuity propulsion bus 41 surface 40 has with barrel rail 1 surface 2 in barrel rail subassembly 25 open channel 47. During armature movement in the barrel cavity said continuity is continuous sliding electrical continuity. Barrel rail 1 and its surface 2 continuous electrical continuities with aft armature current shunt 37 surface 39 and propulsion bus 41 surface 40 constitute the propulsion bus-aft circuit means of the device. Electric current in armature propulsion bus 41 is towards barrel power rail 26; i.e. from 'j' to 'k'. Propulsion bus electric current exits to the return barrel power rail 26 via the continuous electrical continuity surfaces 42 and 42a of propulsion bus 41 has with the open channel 47 surfaces; i.e. at 'k'. The electric current direction in return power rail 26 is towards the barrel breach; i.e. from 'k' to 'l'. The magnetic fields of the electric current in barrel power rail 26 interacts with the propulsion bus current creating forces therein with cavity axis parallel muzzle directed components. The electric current in return power rail 26 exits the device via connection lug 28 to outside the device. Connection lug 28 is connected to the return terminal of the outside power

supple via circuitry also outside the device. The collection of barrel axis parallel muzzle directed components enumerated above propel an armature for the device towards the muzzle.

[0137] With connection lug 28 of barrel power rail 26 connected via outside circuitry to the positive terminal of the outside power supply, and lug 31 of barrel power rail 29 connected via circuitry outside the device to the return terminal of said power supply, the current path in the device becomes extant with an armature for the device in the barrel cavity. Electric current in the positive barrel power rail 26 is towards the barrel muzzle; i.e. from 'l' to 'k'. The magnetic fields of said current interacts with the electric current in the armature propulsion bus creating forces therein with cavity axis parallel muzzle directed components. Electric current exit barrel power rail 26 to the armature propulsion bus 41 and therein has direction towards the barrel subassembly 25; i.e. from 'k' to 'j'. Electric current in propulsion bus 41 exit to barrel rail1 wherein it has breach direction; i.e. 'j' to 'i'. The magnetic fields of barrel rail 1 electric current interact with the propulsion bus 41 electric currents creating therein forces with cavity axis parallel muzzle direction components.

Electric current exits barrel rail 1 to aft wall conductor of the wall conductor assembly 16 via aft armature current shunt 37; i.e. from 'i' to 'h'. The electric current in aft wall conductor of wall conductor assembly 16 is toward the wall assembly barrel bus 17; i.e. from 'g' to 'f'. The magnetic fields of the aft wall conductor currents interact with the propulsion bus electric currents creating forces therein with cavity axis parallel muzzle directed components. The electric currents in the propulsion bus and aft wall conductor are parallel and oppositely directed and the forces created in the propulsion bus by the magnetic fields of the electric currents in aft wall conductor appear as a repulsive forces on said bus. The aft wall conductor electric current exits to the wall assembly 16 barrel bus 17 wherein its direction is towards the barrel muzzle; i.e from 'f' to 'e'. The magnetic fields of the barrel bus electric current interacts with the propulsion bus electric current creating therein forces with cavity axis parallel muzzle directed components. The barrel bus electric current exits to forward wall conductor of wall assembly 16 with direction therein towards the barrel rail subassembly 25; i.e from 'e' to 'd'. The magnetic fields of the electric current in forward wall conductor interacts with the propulsion

bus electric current creating forces therein with cavity axis parallel muzzle directed components. The electric current in both forward wall conductor and propulsion bus are parallel with like direction and the force created in the propulsion bus appears to be an attractive force towards the forward wall conductor. The electric current exits forward wall conductors to return power rail 29 via forward armature current shunt 34; i.e. 'c' to 'b'. Electric current in the barrel power rail 1 is towards the barrel breach; i.e. from 'b' to 'a'. The magnetic fields of the electric current in barrel power rail 29 interact with the propulsion bus electric current creating forces therein with cavity axis parallel muzzle directed components. The electric current exits return power rail 29 via its lug 31 connection via circuitry external the device to the return terminal of said outside power supply. The collection of cavity axis parallel muzzle directed components noted above propel an armature for the device in the cavity towards the muzzle.

[0138] Figure 10 is an oblique cutaway view of another embodiment of the invention 110 having: one wall conductor assembly 116 and a propulsion bus-aft shunt circuit means which includes barrel rail 101, a cylindrical barrel cavity with a cylindrical armature 132 for the device in the barrel

cavity. The barrel is comprised of to section 111 and 111a with barrel cavity 133 therein and barrel cavity lining 120. Shown are barrel rail subassembly 125 which contains barrel rail 101 of the propulsion bus-aft shunt circuit means and barrel power rail 129 with connection lug 131 extending from the device at the barrel breach end. Armature 132 has in its cylindrical surface shallow open channel 147 intl which barrel rail subassembly extends and in which said assembly travels with armature movement in the barrel cavity. Diametric to the barrel rail subassembly 125 across the barrel cavity is barrel power rail 126 with open channel 127 which is part of the barrel cavity surface. Shown at also at the breach end of the barrel is the connection lug 128 of power rail 126. Shown is wall conductor assembly 116 with barrel bus 117 proximal, parallel and electrically insulated from barrel power rail 126. Shown extending from barrel bus 117 are some of the plurality of uniformly spaced parallel wall conductors 118 each of which have contact means 119 at their end distal the barrel bus 117. Each wall conductor 118 contact means 119 has continuous electrical continuity with an armature current shunt when said shunt is at said contact means 119 barrel cavity location and said conti-

nuity is continuous sliding electrical continuity during armature movement in the barrel cavity. The electrical pathway that propels an armature of the device in the barrel cavity towards the muzzle in the device 110 is very similar that discussed in detail for device 10 in figures 4 through 9.

[0139] With the positive rail and return rail of the device are 129 and 126 respectively, electric current direction in each barrel rails of the barrel rail subassembly is towards the barrel muzzle and the magnetic fields attributable there to interact with the armature propulsion bus electric current creating therein forces with cavity axis parallel muzzle directed components. The direction of the electric current in the return power rail 126 and in the proximal barrel bus 117 of wall conductor assembly 116 is towards the cavity breach and the magnetic fields attributable to said electric currents interact with the armature propulsion bus electric current creating therein forces with cavity axis parallel muzzle directed components. Electric current in forward wall conductor is parallel the electric current in the armature propulsion bus and in the same direction; i.e. from power rail assembly towards return barrel power rail 126. The magnetic fields of forward wall conductor electric

currents interacts with the propulsion bus current creating forces therein forces with cavity axis parallel muzzle directed components. The electric current in aft wall conductor has direction parallel but opposite the current flow in the propulsion bus 141 and the magnetic fields of aft wall conductor electric current interacts with the electric current of the propulsion bus creating therein forces with cavity axis parallel muzzle directed components. The collection of above noted forces on the armature propulsion bus propel the armature in the barrel cavity towards the muzzle.

[0140] With the positive and return barrel power rails 126 and 129 ,respectively, the direction of current flow in the propulsion bus is reversed; i.e. from the positive power rail 125 towards the barrel rail subassembly 125. The electric current in the positive power rail 129 and proximal barrel bus 117 has muzzle direction and the magnetic fields of said currents interact with the propulsion bus current creating forces therein with cavity axis parallel muzzle directed components. The electric currents in the barrel rails populating the barrel rail subassembly are breach directed and the magnetic fields of said currents interact with the propulsion bus electric currents creating

forces therein with cavity axis parallel muzzle directed components. The electric current in forward wall conductor is parallel and like directed the propulsion bus electric current and the magnetic fields of forward wall conductor electric current interacts with the propulsion bus current creating forces therein with cavity axis parallel muzzle directed components. The electric current in aft wall conductor is parallel and oppositely directed the propulsion bus electric current and the magnetic fields of aft wall conductor electric currents interacts with the propulsion bus electric current creating forces therein with cavity axis parallel muzzle directed components. The collection of above noted forces on the armature propulsion bus propel the armature in the barrel cavity towards the muzzle.

[0141] Figure 11 is an oblique view the an armature 132 for the design in figure 10. Shown is armature guide 146. With an armature for the design in the barrel cavity armature guide146 is in rail 126 open channel 127- open channel 127 is part of the barrel cavity 133- where it travels during armature movement in the barrel cavity maintaining proper armature orientation in the barrel cavity. Propulsion bus 141 has an extension with surfaces 142 and 142a into open channel 127 in a mating cutout 146b of

armature guide 146. Surfaces 142 and 142a have continuous electrical continuity the surfaces of open channel 127 of barrel power rail 126 and said continuity is sliding with armature movement in the barrel cavity. Propulsion bus 141 shown has cylindrical surface in the armature cylindrical surface and for additional electrical isolation from the wall conductors at the barrel cavity surface liner should have a thin insulating plastic coat. Insulating element 198 protects the propulsion bus from electrical continuity with the contact means 119 of wall conductors 118. Aft armature current shunt 137 is shown with it surface 138 in the armature cylindrical surface. With the armature 132 in the barrel cavity, surface 138 has continuous electrical continuity with the contact means 119 of aft wall conductor of the wall conductor assembly 116 wall conductors 118. In shallow open channel 147 of the armature cylindrical surface is surface 139 of aft shunt 137 which has, with the armature in the barrel cavity, continuous electrical continuity with barrel rail 101 via its barrel cavity surface 102. Also in channel 147 is surface 140 of the armature propulsion bus which also has, with the armature in the barrel cavity, continuous electrical continuity with barrel rail 101 via its barrel cavity surface 102.

Barrel rail 101 and it said continuities with aft shunt 137 and armature propulsion bus 141 barrel cavity surfaces 139 and 140, respectively, comprise the propulsion bus-aft shunt circuit means in the design. Forward current shunt 134 surface 135 in the armature cylindrical surface has continuous electrical continuity with the contact means 119 of forward wall conductor of the wall conductor assembly 116 wall conductors 118. Surface 136 of forward current shunt 134 is located in armature channel 147 where it has, with the armature in the barrel cavity, continuous electrical continuity with barrel power rail 129 barrel cavity surface 130. Insulating element 108 electrically isolates the forward current shunt from barrel rail 101. With armature movement in the barrel cavity, the continuous electrical continuities with reference to figure 11 are continuous sliding electrical continuities.

[0142] Figure 12 is the armature 132 in figure 11 disassembled. Shown in addition to the elements noted in figurer 11 are the armature channel 154 in which propulsion bus 141 is mechanically fixed or chemically bounded. Also shown is cutout 146b in for propulsion extension with surfaces 142 and 142a. Forward armature current shunt 134 mounts in armature surface relief 150 and aft armature current

shunt mounts in armature surface relief 152.

[0143] Figure 13 is a section of the barrel rail subassembly 125 for the device in 10 at its breach end. Shown mounted in barrel rail subassembly 125 is power rail 129 with its barrel cavity surface 130 indicated and power rail 129 connection lug 131 which in the device extends to outside the body of the device. Also shown mounted in assembly 125 is barrel rail 101 with it barrel cavity surface 102 indicated. The barrel rail subassembly 125 in the device with an armature 132 in the barrel cavity is in open surface channel 147 of said armature.

[0144] Figure 14 is a cutaway illustration of another embodiment of the invention, 210, with an armature 232 for the device mounted in the barrel cavity. Indicated are barrel sections 211 and 211a. Design 210 barrel cavity 233 is asymmetric with a curved lined closed triangular right cross section, a portion of the armature axial extant has similar slightly undersized right cross sections. The wall conductor assembly 216 barrel bus 217 is proximal, electrically insulated from, parallel to, of like or similar length and barrel length location as the barrel rails of subassembly 225. Extending perpendicular from and electrically and physically continuous with barrel bus 217 are the plurality of parallel

wall conductors 218 which are distributed from breach to muzzle along the barrel bus 217 with equal distances of separation between consecutive wall conductors. Each wall conductors 218 extends from the barrel bus 217 to very close proximity the barrel rail subassembly 225 where it has a physically and electrically continuous contact means in the barrel cavity through a mating opening 221 in cavity liner 220. Each wall conductor 218 from the barrel bus to its contact means 219 is electrically insulated from the rest of the device and throughout its length each wall conductor is in very close proximity the barrel cavity surface 220. Alternatively the armatures for the device might have a plastic insulating coating except at the current shunt surfaces in the device circuit path and each wall conductor at its barrel cavity location has continuous barrel cavity surface through most of the barrel cavity perimeter. Barrel rail subassembly 225 hold the full compliment of barrel rails; i.e. the two power barrel rails, 226 and 229 and propulsion bus-aft shunt barrel rail 201. When an armature of the device is in the barrel cavity barrel subassembly 225 is the shallow armature channel 247 and travels therein during armature movement in the barrel cavity. Forward armature current shunt 234 and aft ar-

mature current shunt 237 are also indicated in the drawing.

[0145] As previously noted net effect on the armature 232 propulsion bus 241 of the magnetic fields of the electric current in the barrel rails: power rails 226 and 229, and propulsion bus-aft shunt circuit means barrel rail 201, and barrel bus 217 of the wall assembly 216 armature propulsion is negligible. Armature propulsion in the claimed device is effected the magnetic fields of the electric current in forward and aft wall conductor of the wall conductor assembly 216 wall conductors 218 and said fields interaction with the armature propulsion bus 241 electric current creating forces in the propulsion bus with barrel cavity axis muzzle directed components.

[0146] Figure 15 is a view of an armature 232 for the device in figure 14. With the armature in the barrel cavity 233 barrel rail subassembly 225 is in recess 247. And looking at figure 17 for further reference, the cavity axis parallel continuous channels 205, 206 and 207 The barrel power rail 226 and its barrel cavity surface 227, barrel power rail 229 and its barrel cavity surface 230 and propulsion bus-aft shunt circuit means rail 201 and its surface 202, are in the cavity axis parallel continuous channels 205,206 and

207 of recess 247 in the armature 232. The isolation guide ridges 203 and 203a are in continuous open channels 204 and 204a in armature recess 247 and said ridges maintain electrical isolation between the barrel rail in armature recess 247 and also act as guide and guide ways maintaining proper armature orientation in the barrel cavity and during cavity movement. With the armature in the barrel cavity forward current shunt 234 surface 236 in channel 206 has continuous electrical continuity with barrel power rail 229 via its surface 230. Aft shunt surface 239 in channel 207 has continuous electrical continuity with barrel rail 101 via its surface 102 and propulsion bus 241 surface at one of its ends 240 also in channel 207 also has continuous electrical continuity with barrel rail 101 via its surface 102. Barrel rail 101 and its surface 102 continuous electrical continuity with the propulsion bus 241 and aft current shunt 237 comprise the propulsion bus-aft shunt used in the device. The propulsion bus at its end distal surface 240 has a surface 242 in channel 205 of armature recess 247 and therein it has continuous electrical continuity with barrel power rail 226 via said rails surface 227. During armature movement in the barrel cavity said continuous electrical continuities noted above

are continuous sliding electrical continuities. Also indicated in figure 15 is insulator element 298 on the propulsion bus 241 which protects said bus from electrical contact with wall conductor contact means 119. Also in place but not indicated is insulator element 208 which protects the forward armature current shunt from contact with barrel rail 101.

[0147] Figure 16 is an oblique disassembled view of the armature in figure 15. In addition to the elements indicated in the figure 14 discussion, indicated wherein are open channel 254 in the perimeter to the armature surface which mounts the armature propulsion bus 241. Indicated reliefs 250 and 252 in the armature mount forward armature current shunt 234, and aft armature current shunt 237, respectively. Indicated also is insulator element 208 which mounts in the open channel in forward current shunt 234 between surfaces 235 and 236 and therein protects said shunt from contact with barrel rail 201.

[0148] Figure 17 is a view of a section of the barrel rail subassembly 225 with barrel power rails 226 and 229 along with barrel rail 201 of the propulsion bus-aft shunt circuit means mounted therein.

[0149] Figure 18 is an oblique cutaway view of the topic device to

indicate the currents path therein. In the figure the barrel and barrel cavity surface are removed along with most of the barrel rail assembly and all but forward and aft conductor of the wall conductor assembly 216 wall conductors 218. Various points along the current path in the device are indicated by the italicized letters 'a' through 'n'. With barrel rail 229 the positive rail the electric current therein is towards the barrel muzzle; i.e. from 'a' to 'b'. Barrel power rail 229 surface 230 has continuous electrical continuity with forward armature shunt 234 surface 236 in channel way 206 of armature recess 247 and thereby forward armature current shunt 234 has continuous electrical continuity with the positive barrel power rail 229. Surface 235 of forward current shunt 234 has continuous electrical continuity with contact means 219 of forward wall conductor of the wall assembly 216 array of wall conductors 218 and thereby the electric current direction is from power rail 229 through forward current shunt 234 to forward wall conductor; i.e. from 'b' to 'c' to 'd'. Forward wall conductor in the topic device is also the group of one or more wall conductors 218 with contact means 219 at forward armature current shunt 234 surface 235 location in the barrel cavity 233 at any instant. The

electric current direction in forward wall conductor is towards the wall assembly barrel bus 217; i.e. from 'd' to' e'. The magnetic fields of the electric currents in forward wall conductor interacts with the armature propulsion bus 241 electric currents creating therein forces with cavity parallel muzzle directed components. Forward conductor electric current enter barrel bus 217 of the wall conductor assembly 216 and therein has a barrel breach direction; i.e. from 'f' to 'g'. The electric current exits the barrel bus 217 to aft wall conductor wherein its direction is towards the contact means 219 of said conductors; i.e. from 'g' to 'h'. Aft wall conductor in the topic device is also the group of one or more wall conductors 218 with contact means 219 at aft armature current shunt 237 surface 238 location in the barrel cavity 233 at any instant. The magnetic fields of the aft wall conductor electric currents interacts with the armature propulsion bus electric currents creating forces therein with cavity axis parallel muzzle directed components. Contact means 219 of aft wall conductor have continuous electrical continuity with surface 238 of aft current shunt 237 and surface 239 of aft current shunt 237, which is in channel 207 of the armature recess 247 has continuous electrical continuity with barrel rail 201 sur-

face 202 in said channel; thereby, aft wall conductor have continuous electric continuity through aft current shunt with barrel rail 201 and electric current exits aft wall conductor contact means 219 through aft current shunt 237 to barrel rail 201; i.e. from 'h' to 'i' to 'j'. The electric current direction in barrel rail 201 is muzzle directed; i.e. from 'j' to 'k'. Electric current exits barrel rail 201 to the armature propulsion bus 241 via the continuous electrical continuity that barrel rail 201 surface 202 has with propulsion bus 241 surface 240 in channel 207; i.e. from 'k' to 'l'. The barrel rail 201 and the continuous electrical continuity barrel rail 201 surface 202 has with aft current shunt 237 surface 239 and armature propulsion bus 241 surface 240 constitute the propulsion bus-aft shunt circuit means in the topic design. The electric current direction in the armature propulsion bus 241 is from its surface 240 in armature recess 247 channel 207 to its surface 242 in armature recess 247 channel 205; i.e. form 'l' to' m'. The electric current in the armature propulsion bus flows parallel and in like direction the electric current in forward wall conductor and parallel and opposite the direction of the electric current in aft wall conductor. Armature propulsion bus 241 surface 242 in channel 205 has

continuous electrical continuity with surface 227 of barrel power rail 226, the return rail. The current exits the propulsion bus 241 to barrel power rail 226 via said continuity and therein has breach direction; from 'm' to 'n'. Wherein continuous electrical continuity is indicated with armature movement in the barrel cavity said continuity is continuous sliding electrical continuity.

[0150] When the positive barrel power rail is 226 and the return barrel power rail is 229 electric current flow in barrel rail 226 is towards the muzzle; from 'n' to 'm'. The electric current exits barrel power rail 229 to the armature propulsion bus 241. The electric current direction in the armature propulsion bus 241 is from surface 242 to surface 240 of said bus; i.e. from 'm' to 'l'. Electric current exits propulsion bus 241 to barrel rail 201 of the propulsion bus-aft shunt circuit means wherein it has a breach direction; from 'l' to 'k' to' j'. Electric current exits barrel rail 201 to aft wall conductor via aft current shunt 237 and aft wall conductor contact means 219; i.e. from ' j' to 'i' to 'h'. The electric current direction in aft wall conductor is toward wall assembly 216 barrel bus 217; i.e. from 'h' to 'g' and parallel to the propulsion bus electric current but oppositely directed. The magnet fields of the electric

current in aft wall conductor interacts with the electric current in the armature propulsion bus 241 creating forces therein with cavity axis parallel muzzle directed components. The electric current exits aft wall conductor to wall assembly 216 barrel bus 217 with muzzle direction therein; i.e. 'g' to 'f'. The electric current exits the barrel bus 217 to forward wall conductor and therein has direction from the barrel bus 217 to contact means 219; i.e. from 'f' to 'e' to 'd.' Forward wall conductor electric current is parallel the armature propulsion bus current and has like direction and the magnetic fields of forward wall conductor electric current interacts with the propulsion bus electric current creating forces therein with cavity axis parallel muzzle directed components. The electric current exits forward wall conductor to the barrel power rail 229 via contact means 219 and forward armature shunt 234; i.e. from 'd' to 'c' to 'b'. Electric current in barrel power rail 229, the return rail, has breach direction; i.e. from 'b' to 'a'. The electric current in both barrel rails 229 and 202 are always equal and like directed and the electric current in both rail 226 and barrel bus 217 are always equal and like directed. And the net magnetic fields in the barrel resultant said electric currents is negligible. When the

propulsion bus-aft shunt circuit means is a short current bus in the armature between aft current shunt 237 and the armature propulsion bus at its end proximal said shunt, there is an unbalanced sum of magnetic fields orthogonal the cavity axis which might interact with the armature propulsion bus current. Said magnetic field is approximately the field due to the electric current in the barrel bus 217a. However, as the current path in the armature propulsion bus through this magnetic field is 'out' and 'back' the net resultant axial directed force on the propulsion bus due to said magnetic field should be negligible; however, a large couple is created about a perpendicular to the armature axis in a right section plane through the midpoint of propulsion bus axial extent. There also remains the force of attraction between the propulsion bus-aft shunt current bus in the armature and barrel power rail 229 and the forces of repulsion between said armature current bus and barrel rail 226 and barrel bus 217 which must be accommodated when using this type of propulsion bus-aft shunt circuit means in a design. Methods of accommodation are discussed later with reference other embodiments of the invention.

[0151] Figure 19 is an embodiment of the invention similar to the

design portrayed in figure 4; however, forces orthogonal the direction of armature traverse of the previous design are neutralized by the second wall conductor assembly 316a in the topic design. In the topic design the first wall assembly 316 is in the first barrel cavity wall segment and the additional wall conductor assembly is in the second barrel cavity wall and armature and cavity elements proximal the first cavity wall segment are indicated as first elements and armature and cavity elements proximal the second cavity barrel wall are indicated as second elements; e.g. the armature first side, second wall conductor assembly, etc.. In the electric circuit for the device, wall conductor assembly 316a is in parallel with wall conductor assembly 316 and the electric current arriving at an armature current shunt from a barrel power rail is distributed to both wall conductor assembly 316 and 316a. Wall conductor assembly 316a structure is the mirror image of wall conductor assembly 316 structure about a plane which is parallel to both the wall conductors 318 and barrel bus 317 of wall conductor assembly 316. Contact means 319 of wall conductor wall 318 and the contact means 319a of its opposite wall conductor member 318a have contact with the same armature current shunt at the

same time and with armature movement in the barrel cavity during the same interval of time.

[0152] Shown in the figure is barrel rail subassembly 325 with barrel power rail 329 and barrel rail 301 of the propulsion bus-aft shunt circuit means therein. With an armature 332, for the device in the barrel cavity open channel 347 functions as a guide way; i.e. pathway, for armature guide 345 and open channel 327 in barrel power rail 326 functions as a guide way for armature guide 346. Open channels 327 and 347 are part of the barrel cavity. Channel 347 in the barrel rail subassembly 325 extends the length thereof between the cavity surface 230 of barrel power rail 229 and cavity surface 302 of barrel rail 301. Indicated in the figure is channeling 313a of casing section 311a in which mounts wall conductor assembly 316a. Barrel cavity liner 320a with opening 321a for contact means 319a of wall conductors 318a might be only a thin insulating plastic coating on wall conductors 318 otherwise in the cavity surface. Also indicated in the drawing are connection lug 328 of barrel power rail 326 to outside the device and connection lug 331 of barrel power rail 329 to outside the device. Armature 332 is shown in the barrel cavity 333 with its leading edge therein 343. Indicated also is for-

ward armature current shunt 334; i.e. forward shunt or forward current shunt, and its surface 335 at the contact means 319 of forward wall conductor of the wall conductor assembly316 complement of wall conductors 318 and aft armature current shunt 337; i.e. aft current shunt or aft shunt, and its surface 338 at contact means 319 of aft wall conductor of the wall assembly 316 complement of wall conductors 318.

[0153] Figure 20 is an assembled armature 332 for the device 310 in figure 19. With the armature in the barrel cavity guide 346 is in barrel cavity open channel 327 in barrel power rail 326. Propulsion bus 341 extends into the cutout 346b interrupting armature guide 346 and the surfaces 342 and 342a of armature propulsion bus 341 thereat have continuous electrical continuity with surfaces of open channel 327. With armature movement in the barrel cavity said continuity is continuous sliding electrical continuity. Indicated also are the leading and aft edges of the armature in the barrel cavity 343 and 344. With the armature in the barrel cavity armature guide 345 is in open channel 347 of the barrel cavity in the barrel rail assembly 325. Guide 345 is in armature end cap 353 of the armature structure. Indicated also are the forward current

shunt 334 mounted in the armature with surface 335 which when in the barrel cavity has continuous electrical continuity with contact means 319 of forward wall conductor and forward current shunt 334 surface 336 in armature guide 345 which has continuous electrical continuity with barrel power rail 329 via its surface 330. Armature aft current shunt 337 with surface 338 are indicated and with the armature in the barrel cavity aft current shunt surface 338 has continuous electrical continuity with contact means 319 of aft wall conductor of the wall conductor assembly 316 complement of wall conductors 318. With armature movement in the barrel cavity above said continuous electrical continuities are continuous sliding electrical continuities.

[0154] Figure 21 is an oblique view of the second side of the partition 332 for device 310, disassembled. Indicated is cutout 346b in rail guide 346. Cutout 346b is continuous with channel 354 which extends through the armature ending and continuous with relief 351 in armature guide 345. Armature propulsion bus 341 mounts in channel 354 with its surfaces 342 and 342a in cutout 346b. With the armature in the barrel cavity, propulsion bus 341 via its surface 340a in guide 345 relief 351 has continuous elec-

trical continuity with barrel rail 301 via its surface 302 in open channel guide way 347 of the barrel cavity 333. Forward current shunt 334 with surfaces 335a and 335 mount in relief 350 in the armature body and forward current shunt 334 extension with surface 336 mounts in channel 350b in guide 345 at the end cap 353. Aft current shunt 337 with surfaces 338 and 338a mount in relief 352 in the armature body and aft current shunt 337 extension with surface 339a mounts in relief 352b in guide 345 at end cap 353. With the armature 332 in the barrel cavity 333, forward current shunt 334 surface 335 and aft current shunt 337 surface 338 have continuous electrical continuity with contact means 319 of forward wall conductor and aft wall conductor, respectively, of the wall conductor assembly 316 complement of wall conductors 318. Also forward current shunt 334 surface 335a and aft current shunt 337 surface 338a have continuous electrical continuity with contact means 319a of forward wall conductor and aft wall conductor, respectively, of the wall conductor assembly 316a complement of wall conductors 318a. With the armature in the barrel cavity aft current shunt 337 via its surface 339a in cavity open channel 347 of the barrel rail subassembly 325 has continuous electri-

cal continuity with the barrel rail 301 via the continuous barrel cavity surface 302 of rail 301. The barrel rail 301 and said continuous electrical continuities of aft current shunt 337 and armature propulsion bus 241 with barrel rail 301 comprise the propulsion bus-aft shunt circuit means. Forward armature current shunt 334 via its surface 336 in said open channel 347 has therein continuous electrical continuity with barrel power rail 329. With armature traverse of the barrel cavity above said continuous electrical continuities are continuous sliding electrical continuities.

[0155] Figures 22 and 23 have most of the device 310 in figure 19 not essential to discussion of the designs current path cut away Figure 22 illustrates the circuit path on the first armature side with points along the circuit indicated with italicized lettering "a" through "l". With the positive barrel power rail, barrel power rail 329 in the barrel rail sub-assembly 325, the first point of reference is point "a" on barrel power rail 329 the electric current direction in barrel power rail 329 is towards the muzzle; i.e. from "a" to "b". The magnetic fields of the electric current in barrel rail 329 interacts with the electric current in the armature propulsion bus 341 creating forces therein with cavity axis

parallel muzzle directed components. Point "b" is surface 336 on the extension of forward current shunt 334 into open channel 347 which has continuous electrical continuity with the barrel power rail 329 via its surface 330. With reference to both figure 22 and 23, forward current shunt 334 distributes the electric current to the wall conductor assembles on both sides of the armature; i.e. wall conductor assembles 316 and 316a. Barrel rail 329 has continuous electrical continuity with forward wall conductor of both wall conductor assembly 316 and wall conductor assembly 316a compliments of wall conductors 318 and 318a, respectively, via the continuous electrical continuity of said forward wall conductor contact means 319 (d) and 319a (dd), respectively, with forward current shunt 334 surfaces 335 (c) and 335a (cc), respectively; i.e. from "b" to "c" to "d" and from "b" to "cc" to "dd". Forward wall conductor electric current direction in wall conductor assembles 316 and 316a is towards the wall assembly barrel buses, 317 and 317a, respectively; i.e. from "d" to "e" and "dd" to "ee". The magnetic fields of the electric current in forward wall conductor of both said wall assembles interact with the armature propulsion bus 342 electric current creating forces therein with cavity axis parallel muzzle di-

rected components. Forward wall conductor electric current of said assembles 316 and 316a exit to said assembles barrel buses, 317 and 317a, respectively, with breach direction therein; i.e. from "e" to "f" and from "ee" to "ff". The magnetic fields of the electric current in said barrel bus interact with the electric current in the armature propulsion bus creating forces therein with cavity axis parallel muzzle directed components. The electric current in wall assembly 316 barrel bus 317 and wall assembly 316a barrel bus 317a exit to aft wall conductor of wall conductor assembly 316 and wall conductor assembly 316 a ,respectively, towards their contact means 319 and 319a, respectively; i.e. flow is from "f" to "g" and "ff" to "gg". The magnetic fields of the electric current in aft wall conductor of both said wall assembles interact with the armature propulsion bus 342 electric current creating forces therein with cavity axis parallel muzzle directed components. Aft wall conductor of wall conductor assembly 316 complement of wall conductors 318 have continuous electrical contact with surface 338 of aft current shunt 337 via their contact means 319; i.e. there is continuous electrical continuity between "g" and "h". Aft wall conductor of wall conductor assembly 316a complement

of wall conductors 318a have continuous electrical contact with surface 338a of aft current shunt 337 via their contact means 319a; i.e. there is continuous electrical continuity between "gg" and "hh". Aft armature current shunt 337 combines the electric current arriving via surfaces 338 and 338a and the combined electric current exits the aft current shunt 337 via its extension with surface 339a into open cavity channel 347 in barrel rail subassembly 325 whereat it has continuous electrical continuity with barrel rail 301 via barrel rail 301 continuous cavity surface 302; i.e. flow is from "g" and "gg" to "i". The electric current in barrel rail 301 has muzzle direction; i.e. flow is from "i" to "j". The magnetic fields of the electric current in barrel rail 301 interacts with the armature propulsion bus electric current creating therein forces with cavity axis parallel muzzle directed components. The electric current exits barrel rail 301 to armature propulsion bus 341 via the continuous electrical continuity of barrel rail 301 via it surface 302 with armature propulsion bus 341 via its surface 340a at barrel 301 surface 302. Electric current in armature propulsion bus 341 is directed towards barrel power rail 327; flow is from "j" to "k". Electric current exits armature propulsion bus 341 to barrel power rail 326

via the continuous electrical continuity its surfaces 341 and 34a has with the surfaces of open channel 327 in power rail 326. Electric current in barrel power rail 326 is directed toward the barrel breach; i.e. flow is from k to l. The magnetic fields of the electric current in barrel power rail 326 interacts with the electric current in propulsion bus 341 of armature 332 creating forces therein with cavity axis oriented muzzle directed components. When the armature is moving in the barrel cavity the above noted continuous electrical continuities are continuous sliding electrical continuities. The collection of the above noted cavity axis parallel muzzle directed force components propel the armature 332 in the barrel cavity 333 towards the muzzle.

[0156] When the polarity of the barrel power rails is reversed, i.e. barrel power rail 326 is the positive rail and barrel power rail 329 is the return rail, the direction of the current in the armature propulsion bus is towards the barrel rail subassembly 325. The electric currents in positive barrel power rail 326 and barrel bus 317 and 317a of wall conductor assembles 316 and 316a, respectively, is barrel muzzle directed and the magnetic fields of said electric currents interact with the armature propulsion bus 341

current creating forces therein with cavity axis parallel muzzle directed components. The direction of electric currents in barrel power rail 329 and barrel 301, both located in barrel rail subassembly 325 is towards the barrel breach and the magnetic fields of said electric currents interacts with the electric current in the armature propulsion bus 341 creating forces therein with cavity axis parallel barrel muzzle directed components. Electric currents direction in aft wall conductor of wall conductor assembly 316 compliment of wall conductors 318 and aft wall conductor of wall conductor assembly 316a compliment of wall conductors 318a is towards the barrel power rail 326; i.e. parallel and oppositely directed the electric current in the armature propulsion bus 341. The magnetic fields of said aft wall conductor electric currents interacts with the electric current in armature propulsion bus 341 creating forces therein with cavity axis parallel muzzle directed components. . Electric currents direction in forward wall conductor of wall conductor assembly 316 compliment of wall conductors 318 and forward wall conductor of wall conductor assembly 316a compliment of wall conductors 318a is towards the barrel rail subassembly 325; i.e. parallel and with like direction the electric current in the ar-

mature propulsion bus 341. The magnetic fields of said forward wall conductor electric currents interacts with the electric current in armature propulsion bus 341 creating forces therein with cavity axis parallel muzzle directed components. With said reversed barrel power rail polarity in the device armature propulsion remains muzzle directed with the collection of the above noted cavity axis parallel muzzle directed force components propel the armature 332 in the barrel cavity 333 toward the muzzle.

[0157] Figure 24 is a view of an armature 632 which contains the propulsion bus-aft shunt of the invention. An armature 632 can be used in designs 10 and 310; i.e. designs in figures 4 and 19. When armature design 632 is used barrel bus rails 1 of design 10 and 301 of design310 have a passive role as simple spacers. Forward current 634 shunt surface 635a and aft current shunt 637 surface 638a in an armature 632 in design 10 have a passive role; i.e. have no function. The propulsion bus-aft shunt circuit means in armature 632 is a current bus that spans the short distance between aft armature current shunt 637 and the armature propulsion bus 641 at its end proximal said shunt.

[0158] Figure 25 is a view of armature 632 in figure 24, disassembled. The short current bus 640 integral to and ex-

tending between aft current shunt 637 and propulsion bus 641 is indicated .

[0159] Figure 26 is a cutaway oblique view of a tandem arrangement of two complete embodiments of the invention one the mirror image of the other with their barrel cavities connected at the barrel edges at the barrel buses and which share a common barrel power rail 726. Also armatures for the device are a tandem arrangement of two complete partitions for said embodiment wherein their guide distal the current shunts are connected forming a channel for barrel power rail 726 substantially as shown. This arrangement provides neutralization of the large forces of attraction between armatures carrying the propulsion bus-aft shunt current bus and the shunt proximal barrel power rail.

[0160] Drawing figure 27 is an oblique, part sectioned, part broken away view of the barrel, 411, of a Fauchon-Villeplee based rail gun of the invention for flat projectiles and without field coils. Shown are armature 432 mounted in barrel cavity 433. Each openings 421 into the barrel cavity 433 wall on second side of the cavity give a contact means 419 of a wall conductor 418 of the second wall conductor assembly 416 access for sliding continuity with the sec-

ond forward and second aft current shunts, 434 and 437 respectively, in the second armature side when said shunts are at said contact means location in the barrel wall during the armature movement through the cavity. Shown are the barrel bus, 417a of the first wall conductor assembly 416a, in the first barrel cavity wall and wall conductors, 418a of said first assembly. First and second cooling and access panels 412a and 412, respectively, permit convenient maintenance or replacement of the first and second wall conductor assemblies 416a and 416, respectively, and the rails. Shown are barrel rail group subassembly 425, a convenience for quick maintenance of the device. Assembly 425 has mounted in it one of the two power rails of the invention, the barrel rail of the aft shunt-forward shunt circuit means and the barrel rail of the propulsion bus-aft shunt circuit means. Assembly 425, mounts in a mating channel in the barrel which extends though the length of the barrel cavity where the invention is extant, and has surfaces, including surfaces of said mounted rails which are surfaces of the barrel cavity 433. Assembly 425 is mounted so that each rail of its rail group maintains continuous sliding continuity with its adjacent armature current shunt surface in the invention

current path and in the case of the propulsion bus-aft shunt circuit means also the propulsion bus. In the barrel cavity edge surface across the cavity from the rail group is the second power rail of the invention, 426, which has continuous sliding continuity with mating surfaces of the armature propulsion bus during the armature movement in the barrel cavity. Shown is the terminal 431 at the breach end of the power rail of the rail group which extend through the barrel 411 for attachment of external circuitry to the external power supply.

[0161] Drawing figure 28 illustrate a section of the barrel of the design illustrated in figure 27, disassembled. Shown also are an armature 432 for electromotive propulsion through barrel cavity 433. Shown are channeling 413a in the barrel body 411 in which mounts first wall conductor assembly 416a. The first wall conductor assembly 416a is comprised of first barrel bus 417a and a plurality parallel first wall conductors 418a which extend from and are uniformly distributed along the first barrel bus and electrically and physically continuous therewith and perpendicular thereto. Channeling 413 in the barrel body 411 in like manner mounts the second wall conductor assembly 416. The second wall conductor assembly 416 is comprised of

second barrel bus 417 and a plurality of parallel second wall conductors, 418, which extend from and are uniformly distributed along the second barrel bus and electrically and physically continuous therewith and perpendicular thereto. Also shown are openings 421a in the first side of the cavity surface each for contact means 419a at the end of each wall conductor 418a. The mating channel in the barrel body 411 for mounting rail assembly 425 is shown. Also, shown are open channel 447 extending the length of rail assembly 425 which in the assembly is the part of the barrel cavity which acts as the guide way for armature 432 guide edge 445. Armature guide edge 446 is shown. Guide edge 446 has opening through which the armature propulsion bus 441 extends for continuous siding continuity with the power rail 426 during armature traverse of the barrel cavity. Power rail 426 has open channel 427 its length in which armature 432 guide edge 446 travels during armature movement in the barrel cavity. Shown are the leading edge 443 of the armature and the auxiliary thin resilient membrane 457 to load power rail 426 against the armature propulsion bus 441 surface 442 for continuous sliding continuity during the armature movement in the barrel cavity. Also shown are the first

and second cooling access panels 412a and 412, respectively, which permit access to the first and second wall conductor assembles 416a and 416, respectively. The auxiliary thin resilient membrane material 457 is used at various location in the design to effect loading between elements which without said auxiliary loading means would require closer tolerances in assembly.

[0162] Drawing figure 29 is an oblique view of a section of the barrel rail group subassembly 425 of the barrel. Shown in section in their respective subassembly channels are the barrel power rail 429 and its auxiliary loading means 457, barrel rail 423 of the aft shunt-forward shunt circuit means and its auxiliary loading means 457, and barrel rail 401 of the propulsion bus-aft shunt circuit means and its auxiliary loading means 457. The rail group subassembly 425 along with the rails it retains extend parallel the barrel cavity axis in the assembly. Shown are the guide cavity 447 in the subassembly in which armature guide edge 445 travels during armature 432 traverse of the barrel cavity. Shown also are the guide elements 403 and 403a, which are also electric isolators. Guide elements 403 and 403a are uninterrupted protrusions of uniform cross section into the open channel 447 of the subassembly which

extend parallel the rails of the group the length of the subassembly structure. With supporting reference to figures 30 through 33, guide element 403 and 403a travel in mating channels 404 and 404a, respectively, in guide edge 445 of armature 432. Said isolators 403 and 403a in their respective armature channels, 404 and 404a in addition to maintaining proper spacial alignment of the armature during its motion in the cavity, also help maintain isolation of the current pathways of the rails and their continuous sliding continuities with armature conducting elements from one another.

[0163] In the assembly during an armature movement in the barrel cavity, barrel cavity surface 430 of barrel power rail 429, the power rail surface in the cavity wall, has continuous sliding continuity with surface 436a of the armature first forward current shunt 434a and is otherwise insulated from all other conducting armature elements. During said armature movement, the barrel cavity surface 424 of barrel rail 423, the aft shunt-forward shunt circuit means barrel rail, has continuous sliding continuity with surface 439a of the armature first aft shunt 437a and surface 436 of the armature second forward current shunt 434 and barrel rail 423 thereby supplies the aft shunt-forward

shunt circuit means current path external the armature. During armature movement in the barrel cavity, the barrel cavity surface 402 of barrel rail 401 of the propulsion bus-aft shunt circuit means, maintains continuous sliding continuity with surface 410 of armature propulsion bus 441 and surface 439 of the armature second aft current shunt 437. The barrel rail 401 thereby supplies the propulsion bus-aft shunt circuit means current path between the second aft armature current shunt 437 and armature propulsion bus 441 external the armature.

[0164] Drawing figure 30 is an oblique view of the second side shunt edge of an assembled armature 332 for the device in figure 27. Leading edge 443 and aft edge 444 of the armature in the barrel cavity 433 are indicated. Also indicated is armature guide edge 446 which travels in guide way 427 of barrel power rail 426. End cap 453 of the armature structure is shown and in the assembled armature is integral the armature structure. Armature guide edge 445 is indicated at end cap 453. Indicated also are open channels or groves 404 and 404a in which rail guides 403 and 403a of barrel rail subassembly 425 travel, respectively, to maintain proper armature orientation in the barrel cavity and provide additional electrical isolation be-

tween the barrel rails of the rail assembly 425. The pathway of the barrel cavity surface 424 of barrel rail 423 with an armature in the cavity is parallel and between the open channels 404a and 404. Therein the barrel rail 423 maintains continuous electrical continuity between the first aft current shunt 437a in the first armature side and the second forward current shunt 434 in the second armature side via its continuous electrical continuity with the indicated surfaces 439a of shunt 437a and 436 of shunt 434 in its armature pathway. Barrel rail 423 and said continuous electrical continuities are the aft shunt-forward shunt circuit means. Except for said continuities barrel rail 423 is electrically isolated from other conducting elements of both the barrel and armature. And said continuous electrical continuities between elements that have relative motion with armature motion in the barrel cavity are continuous sliding electrical continuities with armature motion in the barrel cavity.

[0165] The barrel rail 401 surface 402 of the barrel cavity surface is parallel to and on the second armature side of open channel 404 with an armature in the barrel cavity. Also barrel rail 401 maintains continuous electrical continuity between the armature second aft current shunt 437 and

the armature propulsion bus 441 via the continuous electrical continuity rail 401 cavity surface 402 has with both surface 439 of armature second aft shunt 437 and surface 410 of propulsion bus 441. Barrel rail 402 and said continuous electrical continuities are the propulsion bus-aft shunt circuit means. Except for said continuous electrical continuities, barrel rail 401 is electrically isolated from all other conducting elements of the barrel and armature. Also indicated is surface 435 of second forward current shunt 434. With an armature in the cavity, second forward current shunt 434 has continuous electrical continuity with forward wall conductor of second wall conductor assembly 416 via the continuous electrical continuity its surface 435 has with contact means 419 of wall conductors 418 of the second wall conductor assembly 416. Indicated surface 438 of the second aft current shunt 437 maintains continuous electrical continuity with the contact means 419 of aft wall conductor of said wall assembly and thereby maintains continuous electrical continuity between shunt 437 and said aft wall conductor. A wall conductor of a wall conductor assembly is a forward wall conductor only when an armature forward current shunt is at said conductor contact means 419 location in the barrel

cavity wall where it has electrical continuity therewith. Similarly, a wall conductor of a wall conductor assembly is an aft wall conductor only when an armature aft current shunt is at said conductors contact means 419 location in the barrel cavity wall where it has electrical continuity therewith. And said continuous electrical continuities between elements that have relative motion with armature motion in the barrel cavity are continuous sliding electrical continuities with armature motion in the barrel cavity.

[0166] Figure 31 is an oblique view of the shunt proximal guide edge 445 and first side of an armature 432 for the device in figure 27. Shown in addition to elements in the figure 31 discussion above, are the path way of the barrel power rail 429 of rail group subassembly 425, which is parallel and on the first armature side of open channel 404a with an armature in the barrel cavity. Also with an armature in the cavity, power rail 429 surface 430 in the barrel cavity surface has continuous electrical continuity with surface 436a of first forward current shunt 434a in the first side of the armature. Power rail 429 is otherwise electrically isolated from other conducting elements of the armature and barrel, with exception of its own terminal 431 for connection of outside circuitry to an outside power sup-

ply. Shown are surface 435a of first forward current shunt 434a. Surface 435a has continuous electrical continuity with forward wall conductor of the first wall conductor assembly 416a complement of wall conductors 418a, via forward wall conductor contact means 419a. Surface 438a of first aft current shunt 437a in the first side of the armature has continuous electrical continuity with the aft wall conductor of first wall conductor assembly 416a complement of wall conductor 418a ,via aft wall conductor contact means 419a. And said continuous electrical continuities between elements that have relative motion with armature motion in the barrel cavity are continuous sliding electrical continuities with armature motion in the barrel cavity.

[0167] Figure 32 is an oblique view of the armature second side from armature guide edge 446 of an assembled armature 432 for the design in figure 27. In addition to elements discussed above, the surface 442 of armature propulsion buss 441 through the guide edge 446 is indicated. Surface 442 has continuous electrical continuity with power rail 426 channel 427 surfaces with an armature in the barrel cavity. And said continuous electrical continuities between elements that have relative motion with armature

motion in the barrel cavity are continuous sliding electrical continuities with armature motion in the barrel cavity.

[0168] Figure 33 is an oblique view of the second side of a disassembled armature 432 for the design in figure 27. Shown are the armature body with reliefs 450 and 452 in the armature second side in which mount the second forward and second aft current shunts 434 and 437, respectively, and in profile reliefs 450a and 452a in the first side of the armature in which mount first forward and first aft current shunts 434a and 437a, respectively. End cap 453 in the assembled armature is integral to the body of the armature. Channels 411 and 411a in end cap 453 are for mounting the surface 436 extension of the second forward current shunt 434 in the second side of the armature and the surface 439a extension of first aft current shunt 437a in the first side of the armature, respectively. The extension of the second aft current shunt 437 with surface 439 mounts in relief 452b in end cap 453. The end of the propulsion bus 441 with surface 410 mounts in end cap 453 channel 451 in the assembled armature. Channel 454 in the armature body extends through the armature edge 446 (has an opening in edge 446) and propulsion bus 441 mounts in channel 454 with surface 442 in the

opening of channel 454 in edge 446 in the assembled armature.

[0169] Figures 34 are oblique views of the first side of a disassembled armature 432 for the rail gun in figure 27 from the armature guide edge 446. Shown in addition to the elements discussed above are the opening in the armature end guide 446 of channel 454. Surface 442 of the propulsion bus 441 is at said opening in the assembled armature. Also shown are reliefs 450a in the first armature side and 450b in the first armature side of the end cap 453 in which is mounted the first forward armature current shunt 434a in the assembled armature.

[0170] Figures 35 and 36 portray the current pathways in the propulsion device design of figure 27. Figure 35 is a cutaway illustration of the current pathways of the invention in figure 27 on the first armature side. The positive power rail is 429 in the rail group subassembly 425, and the return power rail 426 is across the cavity from the rail group subassembly. In the figures, the cavity walls have been removed along with most of the barrel. Looking to figure 35, electric current direction in power rail 425 is towards the muzzle. With power supplied the device and an armature in the barrel electric current direction is from power

rail 425 to first forward current shunt 434a in the first armature side via the continuous electrical continuity between the cavity surface 430 of said power rail and surface 436a of said shunt. The magnetic fields of the electric current in power rail 425 interacts with the electric current in the propulsion bus 441 creating forces in said bus with cavity axis parallel muzzle directed components. Electric current direction in the shunt 434a is from surface 436a to surface 435a and therefrom to forward wall conductor via the continuous electrical continuity forward wall conductor contact means 419a have with first forward current shunt 434a surface 435a. Electric current from the forward wall conductor of the first wall conductor assembly 416a complement of wall conductors 418a is towards the barrel bus 417a of said assembly. The magnetic fields of the currents in forward wall conductor interacts with the electric current in the propulsion bus 441 creating forces therein with cavity axis parallel muzzle directed components. The electric current in the first barrel bus 417a is towards the breach and its magnetic fields interact with the armature propulsion bus 441 electric current creating forces therein with cavity axis muzzle directed components. The electric current exits first barrel bus

417a to the aft wall conductors of the first wall conductor assembly 416a complement of wall conductors 418a and therein has direction towards the armature first aft current shunt 437a. The magnetic fields of the electric currents in the aft wall conductors interact with the propulsion bus 441 electric current creating forces therein with cavity axis parallel muzzle directed components.

[0171] Wall conductors of the first wall conductor assembly 416a are forward wall conductor during the time interval their contact means 419a have continuous electrical continuity with the first forward armature current shunt 434a surface 435a; i.e. when the armature forward current shunt 434a is at the wall conductors barrel cavity location. Wall conductors of the first wall conductor assembly 416a are aft wall conductor during the time interval their contact means 419a have continuous electrical continuity with the first aft armature shunt 437a surface 438a; i.e. when the armature aft current shunt 437a is at the wall conductors barrel cavity location. With an armature in the barrel cavity forward wall conductor is always extant and forward wall conductor is the group of one or more wall conductors but always at least one wall conductor or its equivalent (in contact means area lapping an armature forward current

shunt surface) having continuous electrical continuity with an armature forward current shunt. With an armature in the barrel cavity aft wall conductor is always extant and aft wall conductor is the group one or more wall conductors but always at least one wall conductor or its equivalent (in contact means area lapping an armature aft current shunt surface) having continuous electrical continuity with an armature aft current shunt.

[0172] The electric current arriving at the first aft current shunt 437a continues from its surface 438a to its surface 439a and therefrom to the barrel rail 423 in the rail group subassembly 425 via the continuous electrical continuity between said armature first aft current shunt 437a surface 439a and barrel cavity surface 424 of barrel rail 423. Electric current in the barrel rail 423 has muzzle direction and its magnetic fields interact with the propulsion bus 441current creating forces therein with muzzle directed components. Electric current exits barrel rail 423 to the armature second forward current shunt 434 in the second armature side via the continuous electrical continuity barrel rail 423 cavity surface 424 has with surface 436 of the second forward armature current shunt 434. With an armature in the barrel cavity, barrel rail 423 and its said

continuous electrical continuities with said first aft current shunt surface and second forward current shunt surface constitute the aft shunt -forward shunt circuit means in the device. Said continuous electrical continuities between elements that have relative motion with armature motion in the barrel cavity are continuous sliding electrical continuities with armature motion in the barrel cavity. Refer now to figure 36 for the remaining current path in the invention.

[0173] Figure 36 is a cutaway illustration of the current pathways of the invention in figure 27 on the second armature side. Electric current passes through second forward current shunt 434 from its surface 436 at the third rail 423 to its surface 435. Electric current continues therefrom to forward wall conductors of the second wall conductor assembly 416 complement of wall conductors 418 via the continuous electrical continuity shunt surface 435 has with forward wall conductor contact means 419. Electric currents direction in forward wall conductor is towards the second wall conductor assembly 416 barrel bus 417 and the magnetic fields of the electric currents in forward wall conductor interacts with the electric current in armature propulsion bus 441 creating therein forces with cavity axis

parallel muzzle directed components. Electric current continues from forward wall conductor of the second wall conductor assembly 416 to the barrel bus 417 of said assembly where in it has breach direction. The magnetic fields of the barrel bus 417 current interacts with the armature propulsion bus current creating forces therein with cavity axis parallel muzzle directed components. The electric current exits barrel bus 417 to the aft wall conductor of second wall conductor assembly 416 complement of wall conductor 418 and the electric current in said aft wall conductor is towards the armature second aft current shunt 437 and the magnetic fields of said aft wall conductor currents interacts with the armature propulsion bus 441 current creating therein forces with muzzle directed components. Electric current continues from said aft wall conductor via their contact means 419 to surface 438 of the armature second aft current shunt 437 via the continuous electrical continuity there between . Electric current passes from surface 438 to 439 in aft current shunt 437 and therefrom to barrel rail 401 of the propulsion bus-aft shunt circuit means, via the continuous electrical continuity between surface 439 of second aft current shunt 437 and surface 402 of barrel rail 401. Electric cur-

rent in barrel rail 401 is muzzle directed and its magnetic fields interact with the propulsion bus 441 electric current creating forces therein with muzzle directed components. Barrel rail 401 electric current exits to the armature propulsion bus 441 via the continuous electrical continuity between surface 402 of barrel rail 401 and surface 410 of armature propulsion bus 441 with an armature in the barrel cavity. Electric current direction in armature propulsion bus 441 is towards the return power rail 426 and the electric current enters the return barrel power rail 426 via the continuous electrical continuity between the propulsion bus 441 surface 442 in armature guide edge 446 and the surface of power rail 426 open guide way channel 427. Electric current in the return power rail has breach direction and exits via connection terminal there connected via external circuitry to the return terminal of the external power supply. Then magnetic fields of the electric current in the return barrel power rail 426 interacts with the armature propulsion bus creating therein forces with muzzle directed components. Said continuous electrical continuities between elements that have relative motion with armature motion in the barrel cavity are continuous sliding electrical continuities with armature mo-

tion in the barrel cavity.

[0174] The current flows in the rails, 429,423 and 401 of the rail group subassembly 425 are towards the barrel muzzle and their magnetic fields interact with the current flow in the armature propulsion creating barrel muzzle directed forces on the armature. The current flows in both wall assembly barrel buses 416 and 416a and proximal return power rail 426 are towards the barrel breach and their magnetic fields also interact with the current flow in the armature propulsion bus creating barrel muzzle directed forces on the armature. The electric currents in aft wall conductor are parallel but oppositely directed the electric current in the armature propulsion bus and the magnetic fields of the current flows in the aft wall conductors of both wall conductor assembles 416 and 416a interact with the armature propulsion bus 441 electric current creating forces in the propulsion bus with muzzle directed components. The electric currents in forward wall conductor are parallel and like directed the electric current in the armature propulsion bus 441 and the magnet fields of the current flows in forward wall conductors of both wall conductor assembles 416 and 416a interact with the current flow in the armature propulsion bus 441 creating forces

therein with muzzle directed components. The collection of above noted forces propel the armature though the barrel cavity from breach to muzzle.

[0175] The magnetic fields forces propelling an armature of the device from barrel breach to muzzle are created along the current path in the following manner when the positive power rail is the power rail proximal the barrel wall buses. Electric current is supplied to the positive rail 426 (the high voltage potential rail) via the power connection means at its breach end by circuit means external the invention attached to the positive terminal of an outside power source. With an armature in the barrel cavity, the electric current in the input power rail is from breach to muzzle and the magnetic field of the electric current in the positive power rail 426 interacts with the current in the armature propulsion bus 441 creating forces in said bus with muzzle directed components. The electric current continues from positive power rail 426 to the armature propulsion bus 441 via the continuous electrical continuity between said power rail 426 barrel cavity channel 427 surface and the propulsion bus 441 surface 442 at said rail when an armature is in the barrel cavity. The electric current continues through the length of the arma-

ture propulsion bus 441 in the armature shunt direction and the propulsion bus current interaction with the magnetic fields in the invention effects the movement of the armature towards the muzzle. The electric current continues from the armature propulsion bus 441 via the propulsion bus-aft shunt circuit means to the armature second aft current shunt 437. In the instant case this circuit exists as barrel rail 401 and the continuous electrical continuity between surface 410 of propulsion bus 441 and cavity surface 402 of barrel rail 401 and the continuous electrical continuity between cavity surface 402 of barrel rail 401 and surface 439 of second aft current shunt 437. The electric current continues in the propulsion bus-aft shunt circuit barrel rail 401 towards the barrel breach, and the magnetic field of said current interacts with the propulsion bus, 441, current creating forces therein with barrel muzzle directed components. The electric current continues from barrel rail 401 to the second aft current shunt 437 in the second side of the armature via the continuous electrical continuity between barrel rail 401 cavity surface 402 and the second aft current shunt 437 surface 439. The electric current continues from the second aft current shunt 437 to the aft wall conductor of the second wall

conductor assembly 416 via the continuous electrical continuity between said aft current shunt 437 surface 438 and aft wall conductor contact means 419. The electric current continues in aft wall conductor towards the second barrel bus 417 of the second wall conductor assembly 416 and the magnetic field of the current in aft wall conductor interacts with the propulsion bus 441 electric current creating forces therein with muzzle directed components acting on the armature 432. The electric current continues from said aft wall conductor to the barrel bus 417 of the second wall conductor assembly 416 in the barrel muzzle direction and the magnetic field of the current in said barrel bus 417interacts with the propulsion bus 441 current creating therein forces muzzle directed components. The electric current continues from the second wall conductor assembly 416 barrel bus 417 to forward wall conductor of said wall assembly 416 and therein towards the second armature forward current shunt. The magnetic field of the current in said forward wall conductor interact with the propulsion bus 441 current creating forces therein with muzzle directed components. The electric current continues from said forward wall conductor to the second forward current shunt 434 in the second

side of the armature via the continuous electrical continuity between forward wall conductor contact means 419 and surface 435 of said forward current shunt 434. The electric current continues from the second forward current shunt 434 to the first aft current shunt 437a via the aft shunt-forward shunt circuit means detailed above. The electric current direction in barrel rail 423 is towards the barrel breach and the magnetic fields of the current therein interacts with the propulsion bus 441 current creating forces therein muzzle directed components. The electric current path continues from the first aft current shunt 437a to aft wall conductor of the first wall conductor assembly 416a via the continuous sliding continuity between said current shunt 437a surface 438a and the contact means 419a of said aft wall conductor. The electric current direction in aft wall conductor is towards the barrel bus 417a of the first wall conductor assembly 416a and the magnetic field of the current in said aft wall conductors interact with the electric current in the propulsion bus 441 creating therein force with muzzle directed components. The electric current continues from said aft wall conductors to the barrel bus 417a of the first wall conductor assembly 416a and therein continues in a muzzle

direction. The magnetic field of the electric current in barrel bus 417a interacts with the propulsion bus 441 current creating forces therein with parallel muzzle components. The electric current continues from the barrel bus 417a of the first rail wall conductor assembly 416a to forward wall conductor of said assembly and therein towards first forward current shunt 434a. The magnetic field of the current in said forward wall conductor interact with the armature propulsion bus 441 electric current creating threin forces with muzzle directed components. The electric current of said forward wall conductors continues to the forward current shunt 434a in the first side of the armature, via the continuous electrical continuity between forward wall conductor contact means 419a and said shunt 434a surface 435a. The electric current continues from the forward current shunt 434a in the first side of the armature to the barrel power rail 429 proximal said shunt via the continuous electrical continuity of surface 436a of shunt 434a with said power rail 429 cavity surface 430. The electric current direction in the return power rail 429 is towards the barrel breach and the magnetic field of the current in said power rail interacts with the armature propulsion bus current creating therein forces with muz-

zle directed components, the current path continues from said (low potential) power rail via the connection terminal of said rail at the breach end of the invention the return terminal of an outside power supply via circuitry also outside the invention. Said continuous electrical continuities between elements that have relative motion with armature motion in the barrel cavity are continuous sliding electrical continuities with armature motion in the barrel cavity.

[0176] Figures 37 through 41 portray various aspects of an embodiment of the invention for cylindrical armatures. Figure 37 is and oblique sectioned cut away portrayal with the cylindrical armature 580 in the barrel 560 cavity 533. Shown at the breach end of is terminal connection lug 571 for attachment of an output terminal of an external power supply via external circuitry. Shown is the rail group subassembly 525 in which barrel power rail 529, and barrel rails 524 and 501 are mounted parallel the barrel cavity axis. In the device barrel rails are used as element of both the propulsion bus-aft shunt circuit means and aft shunt-forward shunt circuit means. Barrel power rail 565 located distal the rail group 525 and proximal the first and second wall assemblies 516a and 516 barrel buses 517a and 517, respectively, connects via its lug at the barrel breach

to second output terminal of the external power supply via circuitry external the device. The wall assemblies mount in channeling at the inner radius of the barrel body halves 570a and 570, and barrel lining segments 561a and 561, provide the barrel cavity surface, except at the cavity surfaces of the rails and subassembly 525, and where first and second contact means 519a and 519 are at the cavity 533. Shown, partially cut-away, are the spaced distribution of wall conductors 518 of the second wall conductor assembly 516 in the barrel wall on the second side of the armature, and the spaced distribution of wall conductors 518a of the first wall conductor assembly 516a in the barrel wall on the first side of the armature.

[0177] Figure 38 is an oblique view of an assembled armature of the invention embodiment in figure 37. Indicated are the two major section of the armature 580 and 580a, the head section and aft section respectively. The armature propulsion bus branches 595a and 595 are on the first and second side of the armature, respectively, and each branch carries half the electric current in the device. Shown are the armature current shunt subassembly 598 in which mount the current directing armature shunt, 534a, 537a, the first forward and first aft armature current shunts, re-

spectively, and 534 and 537, the second forward and second aft armature current shunts, respectively. Shallow open linear channels 505, 506 and 507 extending axially in the armature section 580 cylindrical surface, through the shunt subassembly 598 cylindrical surface and armature section 580a cylindrical surface are shown. Said channels in armature section 580a are indicated as 505a, 506a, and 507a. With an armature of the device in the barrel cavity, barrel rail 501 used in the propulsion bus-aft shunt circuit, barrel rail 523 used in the aft shunt-forward circuit means and barrel rail 529, the power rail, respectfully, of the rail group subassembly 525 are in these armature channels. The continuous linear open armature axis parallel guide channels or groves 504 and 504a in the armature and shunt subassembly 598 cylindrical surfaces, are between channels 505 and 506 and channels 506 and 507, respectively. With an armature in the barrel cavity channels 504 and 504a are mating channels for guides 503 and 503a of the rail group subassembly 525. Guides 503 and 503a, (seen in figure 39) are in channels 504 and 504a, respectively, of the armature maintaining proper armature physical orientation and electrical isolation of the barrel rails of barrel rail sub-

assembly 525. With an armature in the barrel cavity and with reference to both figures 38 and 39 power rail 529 cavity surface 530 is in armature surface channel 507 wherein it has continuous electrical continuity with surface 536a of first forward current shunt 534a. With an armature in the barrel cavity and when power rail 529 is the rail gun high potential power rail, electric current direction is from said rail via said electrical continuity to surface 535a of shunt 534a and surface 535a has continuous electric continuity with forward wall conductor of wall conductor assembly 516a via their contact means 519a. When power rail 529 is the low potential rail, electric current direction is from forward wall conductor of wall conductor assembly 516a to surface 535a of first forward current shunt 534a via said continuous electrical continuity between contact means 519a of the forward wall conductor and surface 535a. Electric current proceeds from first forward current shunt 534a surface 535a to surface 536a which has said continuous electrical continuity with power rail 529 cavity surface 530 via said electrical continuity. With an armature in the barrel cavity, barrel rail 523 of the aft shunt-forward shunt circuit means and its barrel cavity surface 524 are in armature surface channel 506. It functions therein

to supply the current path between the first aft current shunt 537a and the second forward current shunt 534 with an armature in the barrel. With an armature in the barrel cavity electric current in barrel rail 523 is via the continuous electrical continuity between its cavity surface 524 and first aft current shunt 537a surface 539a and the continuous electrical continuity between its cavity surface 524 and second forward armature current shunt 534 surface 536 and said continuous electrical continuities. When power rail 529 is the high potential rail, electric current in barrel rail 523 is muzzle directed, i.e. from the first aft armature current shunt 537a to second forward armature current shunt 534. When power rail 529 is the low potential rail, electric current in barrel rail 523 is breach directed; i.e. from the second forward armature current shunt 534 to the first aft armature current shunt 537a. With an armature in the barrel cavity, barrel rail 501 of the propulsion bus-aft shunt circuit means and its barrel cavity surface 502 are in armature surface channel 505. It functions therein to transfer current between propulsion rail branches 595a and 595 input surface 510 in channel 505 with which it has via its cavity surface 502 continuous electrical continuity and the second aft armature current

shunt 537 surface 539 in said channel with which it also has continuous electrical continuity via cavity surface 502. With an armature in the barrel cavity, when power rail 529 is the high potential rail, the electric current in barrel rail 501 is muzzle directed; i.e. from the second aft armature current shunt 537 to propulsion bus input surface 510. With an armature in the barrel cavity, when power rail 529 is the low potential rail, electric current in the barrel rail 501 is breach directed; i.e. from propulsion bus surface 510 in armature channel 505 to the second aft armature current shunt 537. Above said continuous electrical continuities between elements that have relative motion with armature motion in the barrel cavity are continuous sliding electrical continuities with armature motion in the barrel cavity.

[0178] Looking to figure 38, insulating element, 508 of subassembly 598, protects the barrel rail 501 in its armature channel 505 from electrical contact with the second forward armature current shunt 534. Insulating element 509 of subassembly 598, protects the power rail 529 from electrical contact with the armature first aft armature current shunt 537a.

[0179] Figure 39 is an oblique disassembled view of an armature

of the design portrayed in figure 37. Shown in addition to armature elements already discussed are forward section 580 and aft section 580a of the armature which as an assembly is also indicated by 580. Shown in profile at the back of section 580a is guide way channel 512 for barrel power rail 565, when the armature is in the barrel cavity. Armature propulsion bus circumference branches 595 and 595a each have surfaces at channel 512 which have continuous electrical continuity with the barrel cavity surface of power rail 565. Said propulsion bus branches extend from propulsion bus segment 591 which mounts in channeling behind the shunt subassembly 598 and segment 591 has extension with surface 510 through channel 551 in subassembly 598 to the rail channel 505. Circumferential propulsion bus branches 595 and 595a seat in open channels 596 and 596a in the armature, respectively. In the assembled armature, subassembly 598, mounts in open channels 599 in 580 and 599a in 580a. Shown in subassembly 598 surface at the barrel cavity surface are reliefs 550, 552, 550a and 552a in which mount, armature current shunts 534, 537, 534a and 537a respectively. Insulation insert 509, insulates barrel power rail 529 in channel 507 from contact with the first aft armature cur-

rent shunt 537a and insulation insert 508, insulates barrel rail 501 in channel 505 from contact with the second forward armature current shunt 534 with the armature in the barrel cavity. Insert 509 mounts with first aft armature current shunt 537a in relief 552a of shunt subassembly 598 and insert 508 mounts with second forward armature current shunt 534 in relief 550 of said subassembly.

[0180] Figure 40 is an oblique view of a section of the rail group subassembly 525 in the rail gun of figure 14. Subassembly 525 permits rapid replacement of the barrel rails in the invention, but barrel rails might otherwise be mounted individually in the barrel. The subassembly structural material is preferably of insulating, ceramic or plastic, although it might be conducting metal as long as the individual rails are electrically insulted from the structure in their mountings therein. Shown also are the guides (guide rails) 503 and 503a which straddle barrel rail 523 the length of the barrel cavity and with an armature 580 in the barrel cavity said guides are in groves or open channels 504 and 504a respectively in the cylindrical surfaces of said armature.

[0181] Figure 41 is an oblique part sectioned, part broken away view of the current pathway in the propulsion device of

figure 37. The barrel material including the barrel cavity liner are removed. Only sections of the first and second wall conductor assemblies 516a and 516, respectively, and a small segment of the rail group subassembly 525 and rail therein remain of the barrel in the illustration. With barrel power rail 529 in the barrel rail group sub-assembly 525 the high potential rail, the electric current in power rail 529 is towards the barrel muzzle with an armature of the device in the barrel cavity. The magnetic fields of power rail 529 electric current interacts with the current flow in both branches, 595a and 595, of the armature propulsion bus creating forces therein with muzzle directed components. Barrel power rail 529 is in open channel 507 in the armature 580. Therein its barrel cavity surface 530 has continuous electrical continuity with surface 536a of the first forward armature current shunt 534a. Electric current is from power rail 529 via said continuous electrical continuity with the first forward current shunt 534a and therefrom to forward wall conductor of wall conductor assembly 516a complement of wall conductors 518a via their contact means 519a continuous electrical continuity with forward shunt 534a surface 535a. Electric current in forward wall conductor is toward

the barrel bus 517a of the first wall conductor assembly 516a. The magnetic fields of the current in forward wall conductor interact with the electric current in armature propulsion bus branch 595a and therein creating forces with muzzle directed components. Electric current in the first barrel bus 517a is towards the barrel breach and the magnetic fields of said barrel bus electric current interacts with the electric current in both branches of the armature propulsion bus creating forces therein with muzzle directed components. The electric current exits said barrel bus to aft wall conductor of wall conductor assembly 516a and has direction therein towards the rail group sub-assembly 525. The magnetic fields of the electric current in said aft wall conductor interact with the electric current in propulsion bus branch 595a creating forces therein with muzzle directed components. Electric current flow in said aft wall conductor exit to the first aft armature current shunt 537a via the continuous electrical continuity aft wall conductor contact means 519a have with surface 538a of the first aft current shunt 537a. Electric current in said aft current shunt is from surface 538a, under the insulating insert 509 -which has a portion of the armature power rail channel 507 in its surface- reemerging at aft

current shunt 537a surface 539a in the armature open channel 506 for barrel rail 523 of the aft shunt-forward shunt circuit means. The aft shunt-forward shunt circuit means maintains continuous electrical continuity between the first aft current shunt 537a and the second forward current shunt 534 of an armature in the barrel. Power rail 523 is in open channel 506 with an armature in the barrel cavity therein has continuous electrical continuity with the first aft current shunt surface 539a and the second forward current shunt 534 surface 536 also located channel 506. Electric current in power rail 523 has barrel muzzle direction; i.e. from the first aft armature current shunt 537a to the second forward armature current shunt 534. The magnetic fields of the electric current in power rail 523 interacts with the electric current in both branches, 595a and 595, of the armature propulsion bus creating forces therein forces with muzzle directed components. Electric current in the second forward armature current shunt 534 travels from surface 536 in the power rail channel 506 under insulating insert 508 - which has a portion of the armature barrel rail channel 505 in its surface- reemerging at surface 535 of said shunt. Surface 535 of second forward current shunt 534 has continuous

electrical continuity with forward wall conductor via their contact means 519. Electric current from second forward current shunt 534 surface 535 to said forward wall conductor has barrel bus 517 of the second wall conductor assembly 516 direction. The magnetic fields of the electric current in said forward wall conductor interact with electric current in armature propulsion bus branch 595 creating therein forces with muzzle directed components. Electric current in the second barrel bus 517 is towards the barrel breach and the magnetic fields of said electric current interacts with both armature propulsion bus branches 595a and 595 electric currents creating forces therein with muzzle directed components. Electric current in barrel bus 517 exits to aft wall conductor of wall conductor of the second wall conductor assembly 516 complement of wall conductors 518 and therein electric current direction is towards the barrel rail assembly 525. The magnetic fields of electric current in said aft wall conductor interact with the electric current in propulsion bus branch 595 creating forces therein with muzzle directed components. Electric current in said aft wall conductor exit via their contact means 519 to second aft current shunt 537 surface 538. Electric current in second aft current shunt 537

is from its surface 538 to its 539 which has continuous electrical continuity in armature barrel rail channel 505 with barrel rail 501 of the propulsion bus-aft shunt circuit means. Barrel rail 501 is part of the propulsion bus-aft shunt circuit means and maintains continuous electrical continuity between the second aft current shunt 537 surface 539 and the armature propulsion bus segment 591 extension with surface 510 in open channel 505 via its cavity surface 502. The electric current direction in barrel rail 501 is towards the barrel muzzle and the magnetic fields of said barrel current interact with the propulsion bus branches electric current creating forces therein with muzzle directed components. Barrel rail 501 electric current exits to propulsion bus segment 591 via its extension with surface 510 in open channel 505. Armature propulsion bus segment 591 distributes said current equally between armature propulsion bus branches 595a and 595. And the electric current in the propulsion bus branches 595a and 595 is towards the low potential barrel power rail 565 proximal the wall assembles barrel bus where each propulsion bus branch has continuous electric continuity with power rail 565. The electric currents of the propulsion bus branches combine in low potential barrel

power rail 565 and therein travel towards the barrel breach where it exits via power rail 565 connection lug attached to external circuitry to the low potential terminal of the outside power supply. The magnetic field of the electric current in the barrel power rail 565 interacts with the electric current in the branches of the propulsion bus creating forces therein with muzzle directed components. Above said continuous electrical continuities between elements that have relative motion with armature motion in the barrel cavity are continuous sliding electrical continuities with armature motion in the barrel cavity. The above noted cavity axis parallel muzzle directed force components acting in the propulsion bus branches act collectively propelling the armature in the barrel cavity towards the muzzle.

[0182] When the barrel power rial potentials are reversed, i.e. barrel rail 565 has electrical continuity with the positive terminal of an outside power supply and barrel rail 529 has electrical continuity with the return terminal of said outside power supply. Electric current in barrel power rail 565 is towards the barrel muzzle and its magnetic fields interact with the current flow in each armature propulsion bus branch 595a and 595 creating forces therein with

muzzle directed components. The electric current exits power rail 565 to said propulsion bus branches and therein travel towards the barrel rail subassembly 525. The electric current from the propulsion bus branches combine in armature segment 591 and exits via said segment extension with surface 510 to the barrel rail 501 of said propulsion bus-aft shunt circuit means wherein it travels towards the barrel breach. The magnetic fields of the electric current in barrel rail 501 interacts with the electric current in the propulsion bus branches creating forces therein with muzzle directed components. The electric current in barrel rail 501 exit via the second aft armature current shunt 537 to aft wall conductor of wall conductor of second wall conductor assembly 516 complement of wall conductors 518 and has direction therein towards barrel bus 517. The magnetic fields of the current in said aft wall conductor interact with the electric current in propulsion bus branch 595 creating forces therein with muzzle directed components. Said electric current exits to second wall assembly 516 barrel bus 517 and therein has barrel direction. The magnetic fields of the electric current in barrel bus 517 interact with the current in both branches of the propulsion bus creating forces therein

with muzzle directed components. The electric current exits barrel bus 517 to forward wall conductor of second wall assembly 516 complement of wall conductors 518 with direction therein towards the barrel rail assembly 525. The magnetic fields of the electric current in said forward wall conductor interacts with the electric current in the propulsion bus 595 creating forces therein with muzzle directed components. The electric current passes from said forward wall conductor to barrel rail 523 of the aft shunt-forward shunt circuit means via the second forward armature current shunt. The electric current in barrel rail 523 is towards the barrel breach and its magnetic fields interact with the electric current in both propulsion bus branches creating forces therein with muzzle directed components. Electric current in barrel rail 523 exit via the first aft armature current shunt to aft wall conductor of first wall conductor assembly 416a complement of wall conductors 418a. Said aft wall conductor electric current direction is towards the barrel bus 417a of the first wall conductor assembly 416a. The magnetic fields of said electric current interact with electric current in the propulsion bus branch 595a creating forces therein with muzzle directed components. Electric current in said aft wall con-

ductor exist to barrel bus 417a with direction therein towards the barrel muzzle. The magnetic fields of the electric current in barrel bus 417a interacts with the electric current in both armature propulsion bus branches 595 and 595a creating forces therein with muzzle directed components. The electric current exit barrel bus 471a to forward wall conductor of first wall conductor assembly 416a complement of wall conductors 418a wherein it travels towards the barrel rail subassembly 525. The magnetic fields said forward wall conductor current interact with the electric current in propulsion bus branch 595a creating therein forces with muzzle directed components. The electric current exit said forward wall conductor to barrel power rail 529 and therefrom exits the device to the low potential terminal of the outside power source via circuitry outside the device. The magnetic fields of power rail 529 electric current interacts with the current in both propulsion bus branches 595 and 595a creating forces therein with muzzle directed components. The above noted muzzle directed force components acting in the propulsion bus branches act collectively to propel the armature towards the cavity muzzle. Thus regardless the polarity of the barrel power rails the armature is propelled

in the barrel cavity towards the muzzle.

[0183] Figures 42 and 43 are an embodiment of the invention wherein the aft shunt-forward shunt circuit means and the propulsion bus-aft shunt circuit means are each a barrel bus in the armature that when in the barrel cavity are parallel barrel power rail and cavity axis. Being within the armature and parallel the cavity axis said pathways create large lateral forces of attraction between the armature and the proximal power rail; however, because of the tandem nature of the armature and barrel, self evident in the figures, the force manifest the power rail at one shunt edge of the armature is canceled by the oppositely directed and equal force manifest the power rail at the shunt edge of the second halve of the tandem armature.

[0184] The tandem armature in figure 42 has two sets of two such pathways proximal both armature edges at the shunts. Looking to the disassembled halve of the tandem armature, the longest is the aft shunt-forward shunt circuit means, current bus 823 which extends between the first aft armature current shunt 837a which is an integral extension said bus and second forward armature current shunt 834 a second extension of said bus. Current bus 823 replaces the barrel rail used in the aft shunt-forward

shunt circuit means in the preceding design. A second, much shorter current bus 840 between second aft armature current shunt 837 and barrel bus 841 is the propulsion bus-aft shunt circuit means. Current bus 840 replaces the propulsion bus-aft shunt circuit means of the previous design which included a barrel rail. Insulating lamina 825 isolates current bus 823 from current bus 840. Other armature elements and fixtures discussed in previous designs are shown and have indicating numbers with identical last two digits.

[0185] Figure 43 illustrates the tandem barrel for propulsion of the armature in figure 42.

[0186] Figure 44 illustrates a segment of a barrel 910 for a cylindrical armature with a twist. Shown are the twist - constant increase in angular displacement per unit distance of cavity axis about the barrel cavity axis at a fixed radius- of power rails 926 and 929 with increase of axial distance from back to front of the barrel segment along with the angular displacement of consecutive wall conductor contact means 919a and 919 of the first and second wall conductor assembles respectively from back to front of the barrel segment.